AN APPROACH TO EMPATHIC DESIGN FOR ASSISTIVE TECHNOLOGY

by

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Abstract

The levels of income and employment rates of people with disabilities are often lower than those without them. An effective way to free disabled people from these circumstances would be to design proper job accommodation for them. Ordinarily, physical conditions severely restrict their ability to carry out their work efficiently unless they have are provided with appropriately designed assistive technology (AT). However, due to the physical conditions unique to each disabled person, understanding the requirements of a disabled person is often a challenge to an AT designer.

The aims of this research were to develop a design model for an empathy tool that would assist in the process of designing AT for job accommodation, and to explore the relationship between the use of empathy tools and the improvement of design elements in job accommodation AT.

The design models employed were developed by analysing interviews with AT users and examining the results of observations and a literature review. The model was then used to build an empathy tool to be used in designing job accommodation AT for a selected subject; the empathy tools were used in a series of assessments of designer users. The results show that, when compared with tools used in traditional design briefs, empathy tools can successfully help designers to improve design elements in terms, respectively, of their understanding of users' physical abilities (22 per cent), work requirements (26.6 per cent), ergonomic requirements (22.8 per cent), and environment characteristics (21.4 per cent). Meanwhile, it is difficult for the tool to improve upon other design elements, about which one must learn by gaining design experience.

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Chapter 1

Introduction

1.1 Research Background

Since its development in the 1980s, the concept of user-centred design has been widely used in the design of many facets of life, including interiors and products. The concept has successfully helped designers improve their design work, enabling them to better accommodate the desires of users, especially the elderly. The design concept can also allow designers of AT to improve the lives of people with disabilities by enabling the designer to better understand their situations.

This research focused on the user-centred design concept and on AT for job accommodation. The latter's key functions are to help disabled people in their working environment improve their efficiency and work in comfort.

According to surveys from the World Health Organisation[1] (WHO 2011), there are more than one billion people worldwide living with some form of disability. The surveys define people with disabilities as having "any restriction or lack of ability to perform an activity in the manner or within the range considered normal for a human being" (WHO 1976). A disability can have various causes including disease,

[1] The World Health Organisation (WHO) is the directing and coordinating body for health within the United Nations system. It is responsible for providing leadership on global health matters, shaping the health research agenda, setting norms and standards, articulating evidence-based policy options, providing technical support to countries and monitoring and assessing health trends (WHO 2011).

war, traffic accidents, poor living conditions and unprotected work environments (UN 2011).

If a person has a disability it may mean not only that they have a mental or physical condition but also that they have difficulties connecting with society, which often limits their opportunities to apply for work. In most cases, people with disabilities are on lower incomes than others (Imrie 2006); this is even worse for those without proper jobs. Equal employment opportunities are therefore vital to them.

Although many governments provide their disabled citizens with financial support for their daily lives, a host of research has shown that people with disabilities are the same as other people. They desire more than mere survival; they wish to live independently, go on holidays and work in jobs where they can perform well and contribute to society (Bureau of Employment and Vocational Training 2010 and Clarkson et al. 2003).

However, such aspirations are not taken into account in most workplace situations. One of the most common reasons for the low employment rate among people with disabilities is that the working environment is not suitable for people with disabilities (Chou 2005). Since existing facilities and the working environment are generally designed for healthy workers, employers are often reluctant to make big changes to accommodate disabled workers, which may be expensive to implement.

Appropriately managed job accommodation could solve problems between

employers and disabled people. The process of implementing it would involve evaluating the abilities of the disabled person and analysing any given task and environment, before using ATs or task adjustments to design appropriate job accommodation (Chen 1999). Since the job requirements and the abilities of disabled people would then be matched to each other, any disruption to the employer would be minimized.

Appropriately designed AT is essential for people with disabilities. It could improve their ability to access environments designed for able-bodied people, so they can enjoy everything that others do. AT could also be used in work environments to improve workplace efficiency, reduce occupational injuries and allow users to enjoy a comfortable working environment (Bradfield 1992).

However, to design a piece of AT for a particular job accommodation case requires not only a knowledge of product design but also an understanding of the abilities of the disabled people, as well as consideration of the job-related tasks and environment (Chen 2000). Although an experienced AT expert could create a nearly perfect solution in most cases, the various types of abilities and disabilities are complicated. In some situations, even an expert cannot ascertain the real needs of the subject.

Moreover, users often do not know their own real needs. This comes about because people become accustomed to their current situation, even if that situation involves problems that must be solved (Leonard and Rayport 1997). And even if

they do know what they want, without the proper training, they do not have the required knowledge and skills to design and implement a solution.

Because of these difficulties in ascertaining the requirements of people with disabilities, those users often become dissatisfied with the AT they use. Some studies indicate that ATs are often abandoned.

This is a terrible situation that could have serious implications: for one thing, an unwanted piece of AT is a waste of the user's money, which could negatively affect their financial situation. Furthermore, unsuitable AT could in fact damage the user's health and worsen their physical condition (Martin et al. 2008).

The concept of user-centred design could be employed to solve problems in the design and adoption of AT. The concept requires that the end user's needs are closely considered at every stage of the design process. Throughout the design process the designer should discern the user's requirements and use this knowledge to develop design concepts, checking the design's progress with the user at each stage of the prototype until the optimal solution is found.

To understand the user, some companies have developed tools to help their designers explore the usability of their products. For instance, the car manufacturers Ford and Nissan employ a specially designed suit (i.e. an empathy

tool[2]) to simulate the physical characteristics of elderly people (Clark 2007, Ford 1999 and Rowley 2008), allowing their designers to experience the physical limitations and difficulties that elderly people live with and that affect them when they are driving, thus enabling those designers to discover the requirements of elderly drivers and improve the usability of their car designs for such users.

However, the process of simulation requires an appropriately designed empathy tool, as an inappropriate one could lead its users astray and render the final product useless. Guidelines for the empathy tool development process are therefore essential.

An empathy tool also allows designers to experience the physical feelings of their target users. Those often complex and multifarious feelings can then be taken into account at the stage of design concept development, changing the design decisions made.

The thesis will focus on the development of an empathic tool design model. The researcher will also use the model to produce an empathy tool that can mimic the physical disabilities of the target subject. The researcher will then ask participant designers to use it, which will allow both AT experts and subjects to evaluate it.

The study will also invite designers to participate in the research by wearing the

[2] Empathy tool: A simulation device to help its users to gain first-hand insights into particular impairment or disabilities.

empathy tool and designing a set of ATs for a particular job accommodation pertaining to a target subject. Analysis and discussion will consequently help discover which design elements will be improved by using the empathy tool.

1.2 Aims and Objectives

1.2.1 Aims

The aims of this research are to develop an empathy tool design model for designing AT and to discover the relationship between the empathy tool and the improvement of design elements in AT design.

1.2.2 Objectives

The objectives of the research are:

- To review the relevant literature in the areas of disability research, AT, job accommodation and design methodology in order to provide the background to the research and to gather useful information.
- To investigate the lifestyles and the living and working spaces of people with disabilities, as well as the ATs they are using, in order to understand what they need from AT design.
- To examine the user research methods of Taiwanese designers and their opinions on the empathy tool, in order to determine if it is possible to use empathy tools in the design industry.
- To use the collected data to develop an empathy tool design model, and to practice with selected subjects to prove the model's efficiency.

- To investigate which design elements are improved through use of the empathy tool, and to provide suggestions for further research.

1.2.3 Success Criteria

In order to evaluate the achievements of this study, the researcher has stipulated the following success criteria:

To evaluate an empathy tool design model, the researcher should follow the model for producing an empathy tool, which should then successfully undergo an evaluation process that includes assessment by the subject as well as by AT design experts and the user. The subject and the AT experts should agree that the tool is capable of simulating the subject's disabilities and difficulties, while the user must be able to state that the tool poses no physical risk and is very easy to use.

To identify areas in which the design could be improved, the researcher should invite participating designers to produce designs works before and after using the tool; a ranking system should be constructed to evaluate such improvements, and AT design experts should be invited to judge them.

1.3 Methodology

1.3.1 Documentary Research

A general literature search related to the subject area was undertaken as outlined below, with the results being divided into two categories. Firstly, the literature

relating to background information regarding people with disabilities, as well as design guidelines and user experiences with AT and job accommodation, is reviewed in Sections 2.2 to 2.4. Secondly, the existing literature on user-centred design concepts and related design methods is summarised in Section 2.5. This literature helped the researcher to develop a design guideline for the development of an empathy tool.

1.3.2 Interviews and Visits

Because of the lack of up to date published material relating to AT users, it was essential to visit and interview people with disabilities. This helped the researcher to better understand users' opinions and the current problems regarding AT. In order to gather opinions on the empathy tool, it was also necessary to conduct direct interviews with designers. During these visits, it was also possible to observe the environments in which the ATs were to be used. This enabled the researcher to discover potential usability problems of the proposed AT.

1.4 Thesis Structure

The researcher first carried out a series of informal visits and discussions with experienced product designers, people with disabilities and AT experts. The results helped the researcher to develop a clear research framework.

This research consists of four sections:

1. Designer user research

2. Target user research
3. Empathy tool model development and evaluation
4. Empathy tool assessment.

Chapter 1 is an introduction to the research: its motivation, aims, objectives and methodology. It also includes a definition of the research area and research framework.

Chapter 2 is divided into four sections and includes a brief review of the existing literature. The first of these sections is concerned with research into people with disabilities, including disability legislation in relevant countries, and an analysis of the research into the lifestyles and day to day problems of people with disabilities. The second section is a review of research regarding AT and includes design guidelines, the selection process and research on existing problems in AT and how to solve them. The third concerns job accommodation, the process of matching a subject with an occupation and the guidelines for task adjustment and tool modification. It also includes research on existing problems faced by people with disabilities and their employers. The fourth and final section relates to the concept of user-centred design, information about the concept itself and related design concepts.

Chapter 3 is divided into two parts, the first concerning designer research and the second research into users of AT. In the former, formal interviews with product designers are discussed and analysed. The researcher has learned about design

methods within the design industry, and what designers think about the empathic design method and the designing of AT.

AT user research is an analysis of observations and interviews with selected people with disabilities. The researcher has analysed and recorded the characteristics of their AT and their living and working spaces. Each interviewee's experience and selection of AT was also analysed.

In Chapter 4, the researcher used the data gathered in the previous two chapters to develop a design model for job accommodation AT. The goal of the model is to provide a guideline in production for this specific empathy tool.

Chapter 5 describes how the empathy tool design model was realized. The researcher initially selected a suitable subject, and then analysed their working environment, tasks and physical characteristics. A comparison of the differences in physical ability between able-bodied designers and the subject was drawn and the results of the comparison were taken into account during the creation of the design rationales for the empathy tool design. An empathy tool was then developed and produced in the workshop.

The empathy tool was used in a series of evaluations, the results demonstrating that it successfully limited the physical abilities of the designer, thereby allowing them to simulate the actions of the design's subject.

Chapter 6 comprises the assessment of the empathy tool designed and evaluated in Chapter 5. The researcher invited several designers to participate in the assessment. At each of the several stages they were given a different level of design brief and asked to design an AT for the subject in his job accommodation. Three AT experts were then invited to evaluate each design, and the results of the evaluation were analysed to find out which design elements in the AT design process could be improved through the use of an empathy tool.

In Chapter 7 the results of previous chapters are analysed and discussed, and the research limitations are defined. After a conclusion on the study's findings, some recommendations for further research are given.

1.5 Related Work

Since Dorothy Leonard and Jeffrey F. Rayport published the article "Sparking innovation through empathic design" in 1997, empathic design research has thrived. In the article, the authors appeal to industry to consider the feelings of users as they design products and services.

Fig.1: BT700 (OZLER 2011)

In the field of industry, as the elderly population has increased rapidly in recent decades, so car manufacturers have started to place an emphasis on the elderly user market. The vehicle manufacturer Ford uses an empathy tool called a

“third age suit”, which represents the physical conditions that elderly people live with. Engineers are encouraged to use the experiences they gain from the suit to design cars for the elderly driver (Ford 1999). Other vehicle manufacturers such as Nissan and Toyota also use a similar empathy tool to improve the design of their cars for the elderly user market (Rowley 2008).

The empathy tool is used not only by vehicle manufacturers, but is also widely used in various other areas of design work. For instance, the design company Alloy Ltd uses interviews and empathy tools to simulate various disabilities to understand the experiences of their users. Alloy Ltd successfully designed the telephone BT 700 for their client, British Telecom (OZLER 2011, The British Design Innovation 2011).

Several design companies have employed empathy tools in their basic design methods. For instance, the famous international design company IDEO listed the use of an empathy tool in their IDEO method cards, and defined it as an “easy way to prompt empathic understanding for users with disabilities or special conditions” (IDEO 2003).

In 2000, the Third Age Suit mentioned above in relation to car manufacturers was developed to help understand the needs of the elderly (the third age). It was produced by ICE Ergonomics at Loughborough University. Since then, the suit has been widely used in industry to develop products and services for elderly customers.

Many design education institutes have already used empathy tools as a very important part of their design education and research. For example, the School of Art and Design at the University of Illinois in Urbana-Champaign invited first year design students to temporarily experience disabilities by using wheelchairs or other empathy tools, providing a unique opportunity for those students to experience physical difficulties they could never have fully imagined (McDonagh et al. 2010).

The nursing students at De Montfort University have also experienced the difficulties of aging by using an empathy tool in the form of a suit in a role play workshop. This activity took place in the university's clinical skills centre. As senior lecturer Penny Tremayne noted: "*Empathy is one of the most important aspects of nursing but it can be difficult to teach it to students*" (De Montfort University 2011). Using empathy tools could be the best method by which to enable students to consider appropriate treatment for patients.

Chapter 2

Literature Review

2.1 Disability

2.1.1 Definition

The term “people with disability” has a different definition in different countries, depending on opinion. The world programme of action by the United Nations[3] defines disability as:

> *“Any restriction or lack (resulting from an impairment) of ability to perform an activity in the manner or within the range considered normal for a human being”* (WHO 1976)

This definition focuses on lack of ability. It is broad enough to include almost every type of disability. In contrast, some regulations place more emphasis on the period of disability. For instance, the UK’s Equality Act 2010 defines a disabled person as:

> *“A person (P) has a disability if—*
>
> *(a) P has a physical or mental impairment, and*
>
> *(b) the impairment has a substantial and long-term adverse effect on P's ability to carry out normal day-to-day activities.”* (Equality Act 2010)

Some regulations define it by creating a list of every type of disability, which is

[3] United Nations: Founded in 1945 after World War II, it is an international organisation whose stated aims are facilitating cooperation in international law, international security, economic development, social progress, human rights, and achievement of world peace.

clearer to understand. For example, the People with Disabilities Rights Protection Act of Taiwan 2011 (People with Disabilities Rights Protection Act 2011) defines disabled people as those...

> *"..who with the following deviation or loss resulting from physical or mental impairments, are limited or restricted to be engaged in the ordinary living activities and participation in the society; and they, after processes of evaluation & assessment by the committee composed of professionals from medicine, social work, special education and employment counseling and evaluation, can be regarded as suffering one of the following malfunction categories and issued a disability identification:*
>
> 1. *Mental Functions & Structures of the Nervous System;*
> 2. *Sensory Functions & Pain；The Eye, Ear and Related Structures;*
> 3. *Functions & Structures of／involved in Voice and Speech;*
> 4. *Functions & Structures of／related to the Cardiovascular, Haematological, Immunological and Respiratory Systems;*
> 5. *Functions & Structures of／related to the Digestive, Metabolic and Endocrine Systems;*
> 6. *Functions & Structures of／related to the Genitourinary and Reproductive Systems;*
> 7. *Neuro-musculoskeletal and Movement related Functions & Structures;*

8. Functions & Related Structures of the Skin."

In order to comply with the terms of the present study, the researcher decided to define someone with a disability as a person who has a substantial and long-term mental or physical impairment and is limited or restricted in their engagement in ordinary activities and participation in society.

People with disabilities are often called "the disabled". Many organisations suggest that when speaking or writing to people with disabilities it is important to put the person first, because "the disabled" does not reflect their individuality, equality or dignity. Moreover, the words "person without a disability" is better than the words "normal person", because it implies that a person with a disability is abnormal (ODEP 2010, Stone and Priestley 1996).

Many factors can result in disabilities. These include:

- *War and the consequences of wars and other forms of violence and destruction, poverty, hunger, epidemics and major shifts in population.;*
- *A high proportion of overburdened and impoverished families, and overcrowded and unhealthy housing and living conditions;*
- *Populations with a high proportion of illiteracy and little awareness of basic social services or of health and education measures;*
- *An absence of accurate knowledge about disability, its causes, prevention and treatment; this includes stigma, discrimination and*

misconceived ideas on disability;

- *Inadequate programmers of primary health care and services;*
- *Constraints, including a lack of resources, geographical distance and physical and social barriers, that make it impossible for many people to take advantage of available services;*
- *The channelling of resources to highly specialised services that are not relevant to the needs of the majority of people who need help;*
- *The absence or weakness of an infrastructure of related services for social assistance, health, education, vocational training and placement;*
- *Low priority in social and economic development for activities related to equalisation of opportunities, disability prevention and rehabilitation;*
- *Industrial, agricultural and transportation-related accidents;*
- *Natural disaster and earthquake;*
- *Pollution of the physical environment;*
- *Stress and other psycho-social problems associated with the transition from a traditional to a modern society;*
- *The imprudent use of medication, the misuse of therapeutic substances and the illicit use of drugs and stimulants;*
- *The faulty treatment of injured persons at the time of disaster, which can be the cause of avoidable disability;*
- *Urbanization and population growth and other indirect factors* (UN 2011).

The condition of a person's disability can often worsen due to inappropriate treatment. Unfortunately, up to 80 per cent of people with disabilities live in isolated rural areas in developing countries where medical treatment is very difficult to obtain.

Much disability can be prevented or ameliorated by supporting the people affected with appropriate medical treatment, good sanitation facilities or good living environments. Strong legislation, such as governments making laws to force motorcycle riders to wear helmets, thereby reducing the number of disabilities caused by head injuries, could also prevent the incidence of disability.

Disabilities often have an impact not only on the people directly affected; they also place family members in difficult situations. Limited family resources, the often exorbitant cost of medical treatment and job losses could become serious social problems. The task of reducing the effects of disability is a pressing concern for every nation (WHO 2011).

2.1.2 Current Situation of People with Disabilities

According to UN statistics the number of people with disabilities is rising constantly. (UN 2011) An increase in the elderly population, chronic disease and car accidents often increase the number of sufferers in developed countries. Elsewhere the problems of war, environmental pollution, natural disasters and poor living conditions are the main reasons for disability (UN 1983).

The World Health Survey has shown that countries with a lower average income often have a higher rate of disability. Areas of low income, poor educational provision and low employment rates are also related to higher levels of disability (WHO 2005).

People with disabilities often experience the following disadvantages:

- Poor health: a wealth of evidence suggests that people with disabilities experience poorer levels of health conditions than the general population. Such conditions include higher rates of health risk and violence. Moreover, an inappropriate rehabilitation service can also worsen the physical conditions of people with disabilities (MOI 2000).

- Lower educational achievements: children with disabilities find it more difficult to attend school than children without them, and their attendance rate is lower. This is more obvious in poor countries. The lack of a barrier-free environment and a suitable specialist educational system are the main reasons for such situation (Pan 2002).

- Less economic participation: people with disabilities are much more likely to be unemployed than those without. In many cases, even though they may be employed, their salaries are often lower than their unimpaired counterparts in the same positions (MOI 2007).

- Higher rates of poverty: people with disabilities experience higher rates of poverty than non-disabled ones, due mainly to high unemployment rates and the costs of AT and of medical treatment.

- Increased dependency and restricted participation: people with disabilities often rely on their families and society to improve their quality of life. A family with one or more disabled members often spends fewer hours working than do other families. In addition, it is often difficult for them to find work if they become unemployed (Holtick and Radnitz 2001).

2.1.3 Population of People with Disabilities

Disability is an element, in part, of the human condition and almost everyone will suffer some kind of impairment, in the long or short term, within their lifetime. Those who live longer will experience further disabilities simply because of ageing.

According to research by the United Nations in 2010, “there are more than one billion people who live with some form of disability, of whom nearly 200 million experience considerable difficulties in functioning”. This equates to 15 per cent of the world population. This number is obviously larger than that found in the research carried out in the 1970’s, which put the figure at 10 per cent. However, the report also mentioned that ‘disability’ is a matter of ‘more or less’, not a matter of ‘yes or no’; there is no international agreement on definitions and statistical methods by which to measure disability, so it is difficult to quantify the size of the world’s disabled population (WHO 1981 and 2011).

2.2 Assistive Technology (AT)

2.2.1 Definition of AT

The US's Technology-Related Assistance for Individuals with Disabilities Act of 1988 was the first act to define AT as:

> *"Technology designed to be utilized in an AT device or AT service". It includes "Any item, piece of equipment, or product system, whether acquired commercially off the shelf, modified, or customized, that is used to increase, maintain, or improve functional capabilities of individuals with disabilities. AT service is directly assisting an individual with a disability in the selection, acquisition, or use of an AT device."* (NICHCY 2012, Lahm and Sizemore 2002 and Morse 2000)

AT encompasses devices designed to improve the abilities of people who experience difficulties in communicating, mobility, learning, working capability and independence. It could also mean services that help people with disabilities in their selection, acquisition of and use of ATs.

2.2.2 Classification of AT

There are various ways to classify AT. Some researchers categorise it in terms of the difficulties it solves, while others do so in terms of its function or level of complication. In the present study the researcher has classified AT by function, as follows:

a. Positioning and setting: An AT that supports its user in a particular position.

Examples include non-slip surfaces on chairs to prevent slipping, and bolsters that support the user in an upright sitting position.

b. *Mobility:* Walking canes for people whose mobility is affected by a weak knee joint are examples of this category, as well as wheelchairs. The latter helps not only those whose lower limbs are affected, but are also of help to people with impaired standing or walking capacities in changing location.

c. *Sensibility:* An AT that can help its user to hear, see or feel. Hearing aids and special computers that translate normal text to Braille are examples.

d. *Communication aid:* These facilitate communication. A very simple example is a blackboard, while a more sophisticated one is a computer-aided communication board that allows a user to construct and pronounce sentences simply by touching the screen.

e. *Upper limb aid:* Prosthetics such as replacement upper limbs are examples of this category.

f. *Self-care aid:* These improve independence. Examples include electric feeders to help users feed themselves, specially designed toilets for users with lower limb disabilities, and enlarged switches to help users with visual or motor disabilities to control electrical tools.

g. *Environment control:* These ATs allow mobility-impaired users to control their environment, as in remote controls for TV, lights and air conditioning.

2.2.3 Design Principles of AT

A piece of AT could be very simple, such as transforming a wooden pole into a walking cane, or very sophisticated, such as a computer-aided communication board. However, simple AT does not mean simple design. An inappropriately designed AT could damage the physical condition of the user (Yeh, 2000). It is therefore essential to set out the principles for AT design.

Baumgrat et al. suggested that the following principles should be followed when developing an AT:

1. The user's environment should be identified, including such elements as the family, leisure activity type, occupation and the user's social position.
2. The user's tasks and activities should be described.
3. The abilities and skills required in the environment should be evaluated.
4. The difficulties involved in the tasks and the disabilities of the user should be considered (Baumgrat et al.1982).

Research from Rothstein and Everson suggests that function and environment are crucial to matching assistive devices with subject needs (Rothstein and Everson 1995). Other research by Wu et al. (2009) advises that in order to choose the right AT device one must consider the user's ability, environment and task. Different

movements, environments and tasks will require the relevant development processes and evaluation methods.

Some research has suggested that parents of younger users would be reluctant to allow their children to look different to others (Kolar 1996). George and King also remark that people with disabilities have their own personalities, and therefore their own preferences concerning the AT that a developer wants to design for them (Shaari and Suleiman 2009). In this instance, the developer should avoid using the image of ‘disabled’ in the final product and should use design techniques to give the AT a more aesthetic feel (George et al. 1997 and King 2001).

The overriding factor in the abandonment of AT is the failure to consider users’ opinions and preferences when selecting the technology (Peterson and Pree 1996). The user’s opinion should be taken into account at every step of AT development, and their goals, perceived needs and preferences should be considered. Those in the user’s social environment should also encourage them to use the AT (Kolatch 2001).

Kintsch and DePaula (2002) suggest that four types of people should be involved in the adoption of an AT: the user, the caregiver, the AT specialists and the AT device developers. These should all work together as a team with the goal of developing a suitable AT for the user. All opinions should be respected and discussed carefully.

Kintsch and DePaula also maintain that successful adoption of AT relies on team

members having the following characteristics respectively:

- Users should be willing to integrate the tool into their daily routine. They should also want to make a change and to try their best to achieve it. They must also be self-disciplined and have a high tolerance for frustration.

- Caregivers should be able to make the effort required to learn to use and personalise the AT and support the user in doing so as well. They should also welcome the changes the use of the tool brings to the social environment.

- AT specialists should have a wide knowledge of ATs and be strongly motivated to learn about new technologies. They should have the patience to collaborate with other team members and be highly sensitive to family values and cultural differences.

- AT developers should understand functional limitations and abilities in order to design AT that is durable, meets users' aesthetic preferences and is easy to use, while remaining highly adaptable.

The AT trial is the most important part of its adoption. It can be determined whether most ATs are useful or not within just a few days. However, some sophisticated ATs can take many months to evaluate (Magiera and Goetz 2001). The trial concerns not only various ATs but also different configurations. Every possibility should be taken into account until the best result is achieved (Burkhauser et al. 1995)

All those involved in the adoption of AT should understand that the process is not simply a one-off affair (Kintsch and DePaula 2002). This is because the condition of the user may change or the AT may need constant adjustment. Team members should therefore take pains to cooperate in any changes, both for the user and the AT.

2.2.4 AT Design Process

Since some AT is very similar to products used in everyday life, but at a higher cost, Peterson and Perr (1996) suggest a selection process:

1. Find an alternative way to do the task. This may be as simple as a modification to time or user posture while engaged in the task.

2. Use commercially available products whenever possible. It is usually easier and cheaper to buy a device that is already commercially available than to purchase a specially designed AT.

3. Use commonly available products in new ways. People with disabilities often use their creativity to transform a common household item into usable AT.

4. Modify and adapt a commercially available device already on the market. Sometimes it is not possible to find a commercially used product that completely matches the user's requirements. However, it may then be possible to adjust

some part of a product or to combine two products to create a new AT.

5. Design and fabricate custom devices as needed. The final and most costly way to produce an AT is to build it from scratch. However, this is also the simplest way to do it.

When there is no commercially available product that matches requirements, and designers do in fact need to design a new AT, Wu (2009) suggests that a specific procedure for assistive device design would be extremely helpful in the design process. Wu specifies four steps in this procedure:

1. *Understand and specify the context of use:* the designer identifies and analyses all the relevant elements:
   a. *User analysis:* the designer uses their observation and normative assessment skills to identify the user's characteristics.
   b. *Task analysis:* the designer uses observation and recording skills to analyse the user's task.
   c. *Environment analysis:* user mapping or brainstorming skills are used to analyse the environment.

2. *Specify user and organisational requirements:* this is in order that the designer can set the design's goals and objectives. This step consists of:
   a. *Identifying design requirements:* the designer could use the data gathered during the previous step to identify the requirements.

b. *Product analysis:* using the user's view to identify tangible and intangible product features.

c. *Design specification:* the designer could use SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis to specify the design. This analysis is widely used in marketing research. In recent years some researchers have also applied it as an AD-SWOT analysis in the healthcare field (Gibis et al. 2001 and Christiansen 2002).

3. *Produce concept designs and prototypes:* the designer sets out and develops a final design concept from which a prototype can be produced. The step could be separated into four further steps:

   a. *Generate concepts:* analytical skills are used to generate a wide range of design concepts.

   b. *Concept selection:* inappropriate or unachievable design concepts are eliminated.

   c. *Present concept:* list the selected concepts.

   d. *Embodiment:* embody the design concepts in a prototype.

4. *User-based assessment:* the user should now be invited to provide their experience, a process that can be classified into:

   a. *Evaluation plan:* the designer should set a standard operation procedure (SOP) for the evaluation process, which should take the key achievement of the AT into account.

b. *Usability evaluation:* to execute the evaluation process.

c. *User-derived feedback:* this is conducted in order to analyse the user's evaluation feedback and use it to refine the prototype.

2.3 Job Accommodation

Once a person has recovered from the accident or disease that caused their disability and is in a stable condition, a method that could help them reassume a normal life is to find an appropriate job for them. Although perhaps partially disabled as regards a particular task, they may still retain capabilities to execute others, just as if they were not disabled.

To place a person with a disability into an appropriate job is meaningful to society. It is not only providing someone with the chance to resume a normal life, but also helps them to live independently, reduce the burden on their family, fulfil their psychological needs and contribute to society (Chiu 2002).

The US Department of Labour (2011) [4] defines job accommodation as "a reasonable adjustment to a job or work environment that makes it possible for an individual with a disability to perform job duties". The main tasks of job accommodation include the improvement of physical accessibility, environmental

[4] United States Department of Labour: a department of the United States government, responsible to foster, promote and develop the welfare of the wage earners, job seekers, and retirees of the United States; improve working conditions; advance opportunities for profitable employment; and assure work-related benefits and rights.

changes, work station modification, provision of assistive devices and job restructuring (Peterson and Perr 1996).

2.3.1 Job Accommodation: the Current Situation

The World Health Survey for 2010 indicated that in 51 selected countries the employment rates were 52.8 per cent for men with a disability and 19.6 per cent for women with a one, compared with 64.9 per cent for men and 29.9 per cent for women without them in the same countries (WHO 2010). Research by the Organisation for Economic Cooperation and Development (OECD)[5] also showed that in 27 countries the employment rate of people with a disability was just over half of those of people without one (OECD 2009). Moreover, when employers came into financial difficulties, disabled workers were often the first to be fired (O'Donoghus 2010).

The worldwide trend seems to be that people with a disability are not accepted by employers, even though governments have set out special regulations to protect the rights of disabled people.

There are many ways to place a person with a disability in a job, ranging from a simple modification of working time to the setting up of a sheltered work environment or arranging help to start a new business (Wang 2002).

[5] Organisation for Economic Co-operation and Development (OECD): is and international economic organisation, its mission is to promote policies that will improve the economic and social well-being of people around the world.

Many governments use regulations to set quotas for people with disabilities. Companies or organisations who do not hire the requisite number of employees who have a disability are fined.

Governments or organisations could also make vocational training programmes available for people with disabilities. This could involve evaluating their abilities and discovering what kind of jobs they want to do, before teaching them working skills and showing them how to live independently. This would also allow them to more easily find a job.

People with some types of disability are not able to work in a normal environment, or with people without disabilities. In these instances, sheltered work could provide them with specially designed environments or special tutors, which could allow them more time to learn life and work skills.

In some cases, if disabled already has the ability to be financially self-sufficient, government or private organisations could assist them with business start up cash, or help them modify their work environment according to their special requirements.

Since people with disabilities often lack the ability to travel to a given workplace during normal working hours, many of them work at home. This has many advantages for people with disabilities, allowing them to enjoy flexible working hours and environments, as well as enabling them to take care of their families while earning incomes. This has been happening in rural areas and countries with

predominantly agricultural economies to a significant extent for a long time. In addition, the Internet has allowed many industrial cities to develop new methods for people with disabilities to work at home (Chou 2005).

Peterson & Perr (1996) specify five types of job accommodation that are normally used in industry:

- *Physical accessibility:* This helps people with disabilities improve their mobility, which can help them travel to work and allow them to stay in touch with others more easily.

- *Environmental change:* Barrier-free work environments are essential to people with disabilities. Many countries have already made regulations that require employers to ensure such environments for all their employees.

- *Workstation modification:* Since ordinary workstations may not be suitable for people with disabilities, they must often be modified to meet their special needs.

- *Provision of assistive devices:* People with disabilities often needs these devices to assist them in their work. Assistive devices allow them to enjoy an efficient and comfortable work experience, and can prevent further deterioration of a disabled person's physical condition.

- *Job restructuring:* In many job accommodation cases, the person with a disability often needs more flexible working time to maintain their condition. Some people

with disabilities can only do part of a task all of which can be performed by people without disabilities, or they may require the implementation of different work processes to perform such tasks. Employers must therefore restructure work times or processes to match the requirements of disabled people.

2.3.2 The Process of Job Accommodation

There is a process for successfully accommodating jobs to the requirements of disabled people, the details of this process are:

1. *Defining the problem:* this falls into two parts

a. evaluating the person with the disability, including their mental and physical abilities and what kind of job they could do

b. analysing the job - what is its main constituent and its basic requirements, and what stage could present a disabled person with difficulties.

2. *Job modification:* as a result of the first step the job could be modified to be suitable for the person by changing the working time or adjusting the work process.

3. *Change job:* if, however, the job cannot be undertaken by a person with a disability, that person may need to move to a new job that is more suitable for their physical condition and working ability.

4. *Facilities adjustment:* some job accommodation may require an adjustment to

the facilities, such as the creation of a barrier-free work environment and the adjustment of the workstation to meet the special requirements of the person.

5. *Employ AT:* a person with a disability often needs AT to improve their work efficiency and make them feel comfortable during their working hours. The job accommodation designer could employ an AT that is already on the market or they could modify such a pre-existing piece of AT to meet the special requirements of the disabled person (Hsu 2005).

6. *Develop a new AT:* some special requirements cannot be easily resolved and it may not be easy to find a suitable AT in the market. Therefore, the designer must develop a specially designed AT to cater for the special requirements of the person with the disability.

7. *Review and redefine:* before the person with a disability finally obtains their position, the job modification or AT must be evaluated by the designer, the person with the disability, the employer and every person concerned with the job accommodation. The goal of evaluation is to discover the efficiency of the accommodation. If it is not possible to improve that accommodation, the original problem must be redefined.

8. Follow up: a job accommodation case does not end when the person with a disability starts their employment. Because the person's personal conditions often change constantly during their working life, the accommodation needs a

long term follow up to discover if any difficulty could be alleviated by job accommodation and AT (Barbara 1998).

2.3.3 Principles of Job Accommodation

A successful job accommodation also relies on certain principles, which have been discussed in many studies.

Peterson and Pree (1996) suggest that in order to determine the appropriate accommodation for a qualified person with disabilities, certain fundamental principles should be followed:

- Form a partnership between the employer and the disabled individual.
- Focus on the individual's abilities, not on the disability.
- Individualise the solutions.
- Keep it simple.
- Apply the least invasive approach.
- Adopt a holistic approach.
- Consider the preferences of the individual with the disability.
- Whenever possible, have the person try out a particular device before purchasing it.

As with the principles of adopting AT, researchers also suggest that job accommodation should not end at any given time. It requires many years of constant adjustment to ensure the accommodation fits the person (Huebner 2000).

The adoption of AT for the purpose of job accommodation should proceed according to the following principles:

- *Detailed evaluation:* This includes personal issues about the physical and mental condition, sensation, abilities and disabilities of the person in question. It also includes social issues, including social support; economic issues concerning the employer's budget, the affected person's financial conditions and the affordability of the required AT; and finally environmental issues regarding a barrier-free work space and colleagues' attitudes (Ci 2002).

- *Essential elements of the job:* This includes the work abilities, knowledge and physical conditions necessary for the job to be completed (Hendricks and Hirsh 1991 and USDOJ 2002).

- *AT:* The usability of the AT that will be used in the job accommodation.

- *Training and review:* Some ATs used in the workplace require essential training and a constant review of the performance of the accommodation (Jang 1998 and Feyen et al. 2000).

2.4 Existing Design Solutions

2.4.1 User-Centred Design

User-centred design is a philosophy developed in the 1990s. The International

Organisation for Standardization[6] (ISO), the world's largest developer and publisher of international standards, founded the ISO 13407 human-centred design processes for interactive systems in 1999. Although the standard restrict the "interactive system" to a "combination of hardware and software components that receive input from, and communicate output to, a human user in order to support his or her performance of a task", the product design industry has employed it as one of their design principles for many years.

The standard gives four rationales for adopting a human-centred design process:

a) It is easy to understand and use.
b) It improves user satisfaction and reduces discomfort and stress.
c) It improves the productivity of users and the operational efficiency of organisations.
d) It improves product quality, appeals to users and can provide competitive advantage.

The standard has characterised several principles for human-centred design, which include:

- The active involvement of the user and a clear understanding of the user and task requirements.
- An appropriate allocation of function between users and technology.

[6] International Organisation for Standardization (ISO): ISO is the world's largest developer and publisher of international standards.

- The iteration of design solutions.
- Multi-disciplinary design (ISO 1999).

The spirit of the principles is that the user's needs must be involved in the design process, their requirements and tasks must be fully understood and a wide range of design methods must also be taken into consideration.

To achieve the rationales, the standard also provides a user-centred design process. The relationship between these six steps is described in Fig.2.

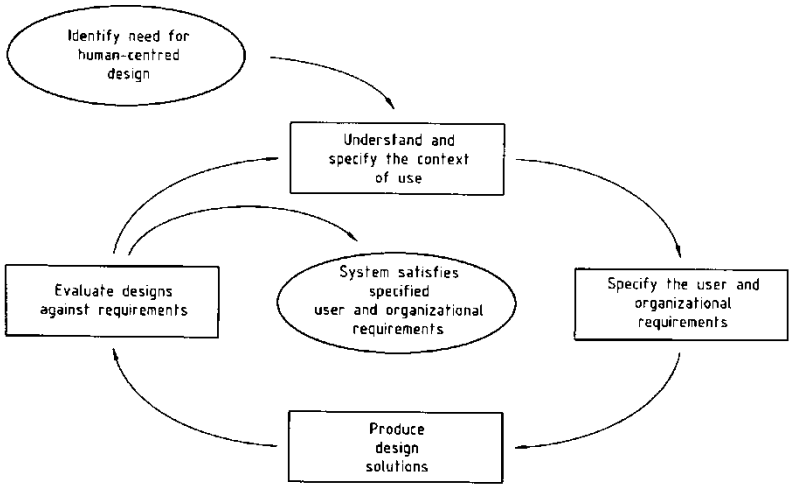


Fig.2: The Process of User-Centred Design (ISO 1999)

The process starts by identifying the need for human-centred design. Information regarding both the individual and the organisation should be collected at this step. The process must also identify every procedure for the succeeding steps, the skills and viewpoints of the individuals and the organisation responsible for the activities, the collection method for feedback documentation of all effective procedures, appropriate milestones in the overall design and development process, and suitable

timescales for each procedure.

The second step is to understand and specify the context of use, and its result should be a description of the relevant user, task and environment characteristics that identify the aspects that will have an important impact on the system design.

The next step is to use this description to specify the user's and the organisation's requirements. Objectives should set by making appropriate trade-offs between the various requirements. The process can then enter the product design stage. The solution will involve activities such as using existing knowledge to develop design proposals, the use of simulations, models and mock-ups to make the design solutions more vivid, the presentation of design solutions to users, allowing them to simulate tasks, and the collection of feedback.

The essential step in human-centred design should take place at every step of the system's cycle. It provides feedback from users in order to improve the design, understands what individuals have been able to accomplish by using the solution, and provides the opportunity to monitor the long-term use of the system.

The results of the evaluation can help decide the next step of the activity. If the results have satisfied the specified user and fulfilled organisational requirements, the design could be implemented long-term monitoring by the design staff begun. However, if the design has not proved satisfactory, the designer should go back a step to understand and specify the context in which the design is being used, re-

thinking the real requirements of the user and the organisation.

2.4.2 Inclusive Design

Every design decision has a potential target user; inclusive design is concerned with enlarging the user group by understanding the user's capabilities, needs and aspirations.

There are many definitions of inclusive design. One of the most popular is that of the British Standards Institute[7] in 2005. It defines inclusive design as "*The design of mainstream products and/or services that are accessible to, and usable by as many people as reasonably possible… without the need for special adaptation or specialised design*." (BSI 2005).

The Inclusive design toolkit website, which was designed by Cambridge University (Clockson 2007), supports a framework for how to execute an inclusive design. The toolkit suggests that the designer should start with four fundamental questions (Fig.3):

1. What are the needs?
2. How can the needs be met?
3. How well are the needs met?
4. What should we do next?

[7] British Standards Institute (BSI): founded in 1901, as the Engineering Standard committee, main areas of activity are: development of private, national and international standards; assessment and certification of management systems and medical devices; testing and certification of products and services provision of governance, risk and compliance solutions; training services.

The questions are answered through the successive cycles of exploration, creation, and evaluation; they are guided by project management, which should determine when to advance from concept development to the next stage in each process.

Fig.3: Four Fundamental Questions Relating to Inclusive Design (Clockson et al. 2007)

To execute an inclusive design, the toolkit also offers advice regarding the principles for the generation of inclusive concepts. Those principles are:

1. *Repeat to refine.* A successful cycle of exploration, creation and evaluation should generate a clear understanding of the needs of all parties involved, and generate better solutions using stronger evidence to meet those needs.
2. *Test early and test often.* A product should be tested as early as possible to allow the designer to discover any critical problems and make necessary changes.
3. *Strive for simplicity.* Keep the design product simple.
4. *It is normal to be different.* To want to do different things in different ways is simply a reflection of the variety of viewpoints that any group of people would exhibit.
5. *Consider the whole user journey.*

6. *Detail matters.* Dig deeper to discover the things that users really do, really want, and really need.
7. *More than just users.* Consider the needs not just of users, but of all the people in their environment.
8. *Challenge assumptions.* List them and discover their associated problems.
9. *Let ideas breathe.* Keep an open mind.
10. *Prove it.* Complement opinions with evidence.
11. *Wear different hats.* Be creative, be critical and know when to switch positions.

The structure can be divided into four parts: management, exploration, creation, and evaluation (Fig.4). The processes start with management: the designer should review progress and plan the following stages, collect common understanding and build a business case to refine the product goals. The management phase also controls the other three parts at every stage.

Exploration is aimed at understanding the user and stakeholder in order to discover the former's real needs. Creation combines simulation, concept development and the construction of prototypes.

The final step is evaluation, in which all concepts and needs are summarised and the product tested by the target users and experts. The results are recorded and presented as evidence, according to which the leading concept is chosen.

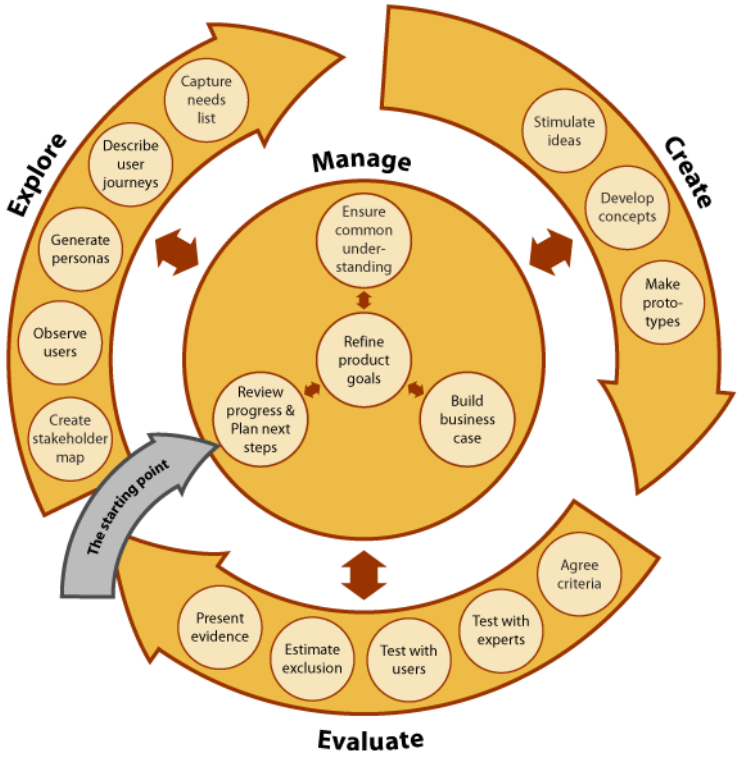


Fig.4: Principles of Inclusive Design (Clockson et al. 2007)

2.4.3 Universal Design (UD)

The purpose of the UD concept is for the design of all products and their environments to be aesthetically pleasing, and to be usable to everyone regardless of their physical condition. The idea was developed in the 20th century from the barrier-free concept. Today, it has been employed in many industries and has become a great market success.

The Centre for UD[8] at NC State University defines UD as:

"*The design of products and environments to be usable by all people, to the*

[8] **Centre for Universal Design: an initiative of North Carolina State University's College of Design, it conducts original research on usability, disseminates information on UD and provides training and technical assistance to the public, business, student, educators and government organisations.**

greatest extent possible, without the need for adaptation or specialized design….The intent of UD is to simplify life for everyone by making products, communications, and the built environment more usable by as many people as possible at little or no extra cost. UD also benefits people of all ages and abilities." (NC State University 1997).

In 1997 the Centre for UD first formally proposed the seven concepts of UD principles. They included the idea of "Design for All", "Design for the Elderly" and "Inclusive Design".

The seven principles of UD are:

1. *Equitable use:* The design is useful and marketable to people with diverse abilities.
2. *Flexibility in use:* The design accommodates a wide range of individual preferences and abilities.
3. *Simple and intuitive use:* Use of the design is easy to understand, regardless of the user's experience, knowledge, language skills or current concentration level.
4. *Perceptible information:* The design communicates the necessary information effectively to the user, regardless of ambient conditions or the user's sensory abilities.
5. *Tolerance for error:* The design minimises hazards and the adverse consequences of accidental or unintended actions.
6. *Low physical effort:* The design can be used efficiently and comfortably and with

a minimum of fatigue.

7. *Size and space for approach and use:* Appropriate size and space is provided for approach, reach manipulation and use regardless of a user's body size, posture or mobility (Centre for UD 1997).

2.4.4 Empathic Design

Empathic design is a user-centred design approach that takes the user's feelings toward a product into account (McDonagh et al. 2010); the goal of empathic design is to identify customers' requirements, including those that customers themselves have not realised.

As Leonardo and Rayport put it in their seminal publication Spark Innovation Through Empathic Design: "Customers are so accustomed to current conditions that they do not think to ask for a new solution – even if they have real needs that could be addressed" (Leonardo and Rayport 1997). Moreover, normal designers often use only their own knowledge to design products, regardless of the real needs of the customers.

Even if some users have discovered problems relating to a product, they lack the design knowledge to change matters. It is also difficult for them to communicate with the product manufacturers.

When developing a new product, empathic design provides a good method for allowing designers to understand their users and discover potential problems

before the product enters the market (Froukje and Merlijn 2009).

In the traditional design process, design quality depends on the designer's personal experience. The empathic design method on the other hand invites the user to become a co-designer, participating and ultimately partnering the designer (Sanders and Danvavate 1999). In order to gain a better empathic understanding, the feeling of the designers is also involved in design development.

The empathic methods work best as a concept search (Kolatch et al. 2003), which is the stage before the concept design. Concept search and concept design are both essential activities at the fuzzy front end of a design.

Good empathic practice relies on observational skills (Koskinen et al. 2003). The designer must observe users using the product, and employ recording devices to capture and analyse the data, which the designer should then use to brainstorm a solution and develop a prototype for a possible solution.

2.4.5 Third Age Suit

Due to the fact that the physical conditions of elderly people are very different to those of the designers, the latter often find it difficult to understand the elderly users of their products. However, with an increasing number of elderly people in most developed countries, the marketplace they constitute has become more prominent and lucrative for product manufacturers. Therefore, companies have started to ask their designers to design for this market.

Fig.5: The Third Age Suit (BBC 2004).

Literature research can support anthropometric measurement data for designers, but the feelings that affect elderly people are difficult to discern. A good method for allowing designers to do just this is to let them experience the physical limitations of elderly people, so they can understand their feelings (Burns et al. 1999).

A third age suit is an outfit “which makes you feel seventy years old” (BBC 2004). It is used to simulate the physical and visual conditions of people aged over 55, allowing designers to experience the limitations of elderly people (Hitchcock et al. 2000). It was first developed by Loughborough University in the UK. The Ford motor company gave it to their engineers and designers to help them understand elderly people, enabling them to design cars suitable to the elderly market.

According to research, on average elderly people lose 25 per cent of their muscle strength compared to when they were young (Hitchcock et al. 2000). The suit mimics this condition by using clothes and a plastic board to bend the body and limbs of the user to simulate the physical limitations of elderly people, as well as coloured glasses to mimic their diminished visual capacity.

The suit has been a great success. Many companies have now started using similar equipment to help their designers obtain a better understanding of elderly people. For instance, the car manufacturers Toyota and Nissan and the transportation company Virgin have all used the suit to help with the design of their products (Rowley 2008).

However, the suit still has its limitations. For example, the effects of pain cannot be simulated. Hearing or balance difficulties are also not considered, nor are breathing difficulties. The timescale relating to ageing or loss of mobility, vision, and hearing is not taken into account either, nor are psychological aspects such as frustration, helplessness, loss of independence and self-esteem, which can only be imagined by the suit's user (Mobilistrictor 2007).

2.5 Summary

The present researcher has concluded from the literature review that the population of people with disabilities is very large, and its distribution is worldwide. Furthermore, although medical treatment could prevent some disability, in many cases people find it extremely difficult to avoid becoming disabled. Poor economic conditions and lower education levels are very common in families containing disabled people. Therefore, when designing AT, the designer should consider its price: AT must affordable as well as easy to use.

Successful adoption of AT depends on understanding the user's abilities and

disabilities, living environment, and lifestyle. If these aspects are ignored, the AT will be deemed unsuitable and will be abandoned after a very short period, wasting money and perhaps, where the AT is inappropriate, causing physical harm.

Job accommodation could help people with disabilities escape from poor economic conditions and live independently. Empathy tools could, as part of that process, be used to develop AT, which could improve the user's work efficiency. Designers' task analyses and design knowledge could improve the AT design.

Empathy tools have been widely used in many industries and in research; some of them have successfully allowed the user to feel what the target subject feels. In this chapter the researcher has reviewed the most famous empathy tool -- the Third Age Suit, which uses a special suit to make users feel they are losing muscle strength and vision, allowing the user to understand the difficulties experienced by elderly people.

However, the level of disability and difficulty the Third Age Suit simulates is determined by statistical average data, which contravenes the principle of job accommodation and AT design, as every design should be customised for an individual user.

Much research into empathy tools also has similar problems; it simply assumes that a given subject has a particular disability, then uses statistical data to mimic the symptoms so as to produce the empathy tool. They then ask participants,

designers or students to wear the tool and measure the differences.

However, the reality is that every disabled person has their own unique level of disability, and that sufferers often have more than one disability. This presents a very different situation from most empathy tool research. Moreover, without a particular subject, researchers can only use their imaginations to evaluate the success of the empathy tool. If that imagination is wrong, then so will their results be.

Chapter 3

Pilot Surveys

3.1 Introduction

The user-centred and empathic design concepts have been developed in the product design industry for many decades and have successfully satisfied their customers. They has also been introduced into Taiwan in recent decades and many books about them have been translated from other languages, allowing designers to understand and implement them.

The present researcher has worked in the design field in Taiwan for many years. In his experience, although the concepts were introduced to Taiwan some time ago, they have not been widely used in the design field. Designers in Taiwan are still using their personal knowledge and skills to design commercial products as well as AT for customers.

The goal of this chapter is to discover product designers' opinions on user-centred and empathic design. Questions were asked of them, such as: "What do you think of user-centred design and empathic design concepts?", "How do you use them to understand your users?" and "Why are you not using them?" The analysis of the answers enabled the researcher to understand the design industry in Taiwan and how to promote design concepts to designers.

The product design industry was introduced to Taiwan in the 1960's and began to

mature in 1985 (Wong and Lin 2008). The Taiwanese government has supported the industry strongly. It has become a very popular occupation nationally; many of the younger generation want to become product designers.

According to statistics sourced from Taiwan's Ministry of Culture (2010), there were 2,470 design companies in Taiwan, which together contributed £155 million to the economy (Ministry of Culture Taiwan 2010).

In the past, a large number of Taiwanese companies undertook work in the original equipment manufacturing (OEM) business. In so doing, these companies have employed effective techniques and cheap labour for manufacturing products. Western companies often sent their orders and design instructions to Taiwan for Taiwanese companies to produce these Western companies' products. Two decades ago, this was a very common business practice.

However, the situation has changed in recent years due to the development of design education in Taiwan, combined with the fact that China has overtaken Taiwan in this kind of manufacturing. Consequently, many Taiwanese companies have had to transform themselves to become original design manufacturers (ODM)[9]. Now, these Taiwanese companies not only manufacture but also create designs for their clients. This combination of design work and manufacturing techniques is a very good one for their clients because the manufacturers often

[9] **Original Design Manufacturer (ODM): a company which designs and produces products branded by another company.**

own the newest techniques and expertise relating to manufacturing products. They are able to use these techniques and knowledge to design brand new products for their clients, something their competitors cannot do. Thus, they are able to achieve a unique selling point in the market.

Moreover, some Taiwanese brands have now become famous market names. For example, the mobile phone company HTC has become one of largest sellers of smart phones in the world. Computer companies ACER and ASUS introduced their small laptop “notebooks”, now famous globally. The bicycle company Giant has become the standard for high quality sports cycles. These success stories have bolstered the confidence of Taiwanese designers.

The types of industry that the majority of Taiwanese companies work in means that most designers are good at designing consumer electronics, such as PCs, mobile phones and digital cameras. But since these companies are mostly based in OEM industries, their designers concentrate on making products with increased functionality than on improving usability. Moreover, they are better at improving existing product designs than generating new design concepts, this lack of originality being a weakness of the Taiwanese design industry.

The aim of the present survey is to discover the methods used by designers to understand their end users, as well as their opinions about empathic design, and whether they would use such design methods in their design work.

The survey uses the following procedure:

1. To review the relevant literature about user research.
2. To identify the most commonly used research methods employed by designers.
3. To ascertain the opinions of Taiwanese designers about empathic design.
4. To identify the reasons for not using the empathic design method.
5. To discover the possible ways of applying the empathic design method to designers.
6. To draw conclusions and make recommendations for future research into the empathic design method.

3.2 Pilot Survey for Designers

The research took place in Taiwan and the researcher set conditions for the selection of interviewees, the criteria for which were:

- The candidate should work in Taiwan as a product designer.
- They should have at least two years' work experience, so as to make them aware of the real situation in Taiwanese design companies.
- They should be aged between 25 and 35. Taiwanese designers mostly start work after they have graduated from university, meaning that they are about 23 years old. Adding on two years of work experience means that the age range had to start from 25.

The researcher looked for interviewees among communities of designers in Taiwan and posted the information on websites to encourage designers to participate in the research.

3.2.1 Survey

The interviews took place in 2009. 12 designers were selected and agreed to participate. The range of their design experience varied from two to six years. Most of the interviewees were consumer electronic product designers, two of them were shoe designers, and one was an interior designer. However, all of them could be classified as product designers.

The researcher visited the interviewees in their work place or met them at coffee shops. He made audio recordings of the interviews and transcribed them for analysis. The interviews were semi-structured, which allowed the interviewees to express their opinions freely.

The questionnaire included three sections. The first contained personal information about age, education, work experience and current occupation. The second asked about the design process and user research methods the interviewees used. The third sought their opinions of empathic design and how Taiwanese designers could be encouraged to use this method. The questions are:

Q1. What type of design education did you receive? How long was it?

Q2. Since graduating from the design education system, what type of design

company have you worked for?

Q3. What type of design work are you working on currently?

Q4. Please explain the design work process you normally follow in your daily work.

Q5. When you need to search for new product information, how do you select your research method?

Q6. When you need to research your end users, how do you select your user research method?

Q7. Do you know a design concept called “User-Centred Design”? What do you think about it?

Q8. Do you know a user research tool called the “empathy tool”? What do you think about it?

Q9. Do you think the empathy tool could help designers to understand their users?

Q10. According to your experience, how could Taiwanese designers be encouraged to use this method?

3.2.2 Results Analysis

In the table below the researcher presents extracts of significance from the interviews, and has combined these with their personal information to try to determine the relationship between each designer and their opinion.

Table 1: Important Sentences from the Interviews

Interviewee	Years of experience	Design area	Quote
A	3 years	Shoe design	• The shoe industry has its size list. We just follow the list to make our design. • Empathic design may take too much time.
B	5 years	Interior design	• We are undertaking customized interior designs; the client tells us what they want. • Some clients have special requirements. We go to his original living space to observe the original design and make improvements. • The concept (of empathic design) is very interesting, but normally we wouldn't have time to do it.
C	6.5 years	Product design	• The structure of our customers is very similar to [that of] our designers, so our designer normally knows what the user's needs are. • If the users are too different to our designers, we will conduct some interviews, so users can tell us what they want. • The electric consumer products of each company are very similar; we do not want to be too different from other competitors, which is the safest way to design. • Normally, we do not have time to do much user research.
D	2.5 years	Product design	• Our users are very similar to our designers, so we can just undertake the user research in our team. • We take more time to observe our competitors than to understand our user. • I do not think my boss would allow us to take time to do this kind of user research
E	5 years	Product design	• The designer's experience is very important, more so than user research. • I often go to the market to observe how users use our products; I think this kind of observation can help me to improve my design knowledge. • I have heard of this kind of research; I think it is interesting and am willing to try it.
F	2.5 years	Shoe design	• We follow standard sizes to make our shoes. • I am not designing shoes with any special function, so I care more about fashion than user requirements. • Normally we do not have time to do this kind of research.
G	6 years	Product design	• Normally we test our products by ourselves, as our designers are very similar to our target users. • If we get time to do more research, we will go to the market to observe our users, and sometimes we will conduct some interviews. • The empathic design method may take up too much time in the design process; I think it is better to use the method in designer training than use it in a special design case.
H	6 years	Product design	• Our user is the general public. I think our designers also belong to the general public, and they understand themselves, so they could design the products for themselves. • If we need to design for people with special needs, we will take the time to interview the user, and his opinions will be considered in the design process. • I think the empathic design method could help our designers understand more about the users, but I am afraid it is very

			difficult to reserve time for this kind of user research in Taiwan.
I	2.5 years	Product design	• The Internet could support us with information, such as competitor information, and the newest design concept and style; It also helps me to know what it is that users want. • My job just fulfils the client's request, so I do not need to do user research in my design work. • The design method is new to me, and it is interesting; if the design work required me to do user research, I would try to use the method.
J	3 years	Product design	• Most of my design information is collected from the Internet. • Our company often follows the biggest competitor's design, so we do not do user research normally. • The design method is good, but I do not think our team leader will let us do it.
K	5 years	Product design	• I think our designers could generate ideas from their work experience. They are also our target group, so they could understand themselves. • If they do not understand the user, they will go to the market to perform user observation. • To do more user research is good for the designers, but the limitations of budget and time are often the biggest problem.
L	3 years	Product design	• Electric consumer product designs are often very similar to each other, even if they are from different companies; so user research is less important in the industry. • Sometimes we have new product needs to provide designs for, and observation and interviews are enough to allow our designers to understand their users. • The design method may allow designers to discover new design concepts from experience, but it is difficult to make time for a particular design case. • I think that if a company uses it in training, progress will be better.

The researcher listed every user research method mentioned by the interviewees and, sorting according to their amount of work experience, tried to discern the most popular user research method in Taiwan. The relationship between design work experience and the methods they used was also investigated.

There were four methods mentioned by the interviewees: user interview, user observation, competitor product observation and market observation. The most popular method was competitor product observation. 10 of the 12 designers used it to gather information on their users. They used the Internet to gather competitors' product information and analysed the products to discover the flow of the user

requirements. They believed that understanding that flow would enable them to identify their customers' preferences, thereby increasing their profit margins.

However, designers who use this method can only ever be followers in the market. It is difficult to generate new design concepts just by observing competitors' products. The reasons given by so many interviewees for adopting this method were that "it is the cheapest and safest way to understand the market" and that "the competitors have already done their user research, so we do not need to spend our budget on it".

Most companies in Taiwan are involved in OEM or ODM. The former firms manufacture products according to the instructions they have received from their clients, so their ability to design products is not essential. Although some companies have developed an ODM business style, they tend to provide their clients with a "me too" product design, which poses less market risk to both companies and their clients.

The second most popular method was user interview and user observation, each of which was mentioned by five designers. These methods are very common in the design industry. Designers interview or observe their end users directly, analyse the results and find out the problems inherent in their products. When designers try to use these methods to discover their users' preferences, the ability to reveal the real meaning of sentences and activities is the key to a successful user research.

Only three designers used market observation to do their user research. They preferred to go to the market to see what users do when they choose products, so they can design goods that would inspire users to purchase them at first contact.

No interviewee used questionnaire, focus group, contextual inquiry, or cultural probe methods to do their user research. Some indicated that a questionnaire survey needed a long time to perform, which they felt posed great difficulties in design work. Many of them also saw themselves as being very similar to their end users, so small group meetings in their design teams would play the same role as focus groups. Most of them had never heard of, much less used, contextual inquiries and cultural probes, and when the researcher introduced these methods to them, they felt that they would be too complicated to apply to actual conditions in the design industry.

3.2.3 Discussion

1. User experience

The interviewees could be divided into two groups: young designers who had less than five years design experience and senior designers who had more than five. Comparing the two groups, it was possible to discover the difference between young and senior designers and their respective preferred user research methods. Table 2 shows that senior designers used more methods to discover their users' preferences than did young designers. User interviews and observation were widely used by the senior designers, whereas the young ones tended to follow their competitors.

Table 2: The Relationship between Design Experience and User Research Methods

Designer	F	I	D	A	J	L	B	E	K	G	H	C
Design work experience	2	2	2.5	3	3	3	5	5	5	6	6	6.5
User Interview						■	■			■	■	■
User Observation	■				■	■			■	■		
Competitor product observation		■	■	■	■	■		■	■	■	■	■
Market observation	■				■		■					

The reasons for the differences could be that senior designers spend more time setting up their concepts in the design process rather than executing their design work, whereas young designers spend more time doing detailed design work than deciding on the direction their concepts will take. User research was often executed at the fuzzy front end of the design process, so that young designers rarely had the chance to join the research.

2. User-centred design

The researcher also asked the interviewees their opinions of user-centred design as he would like to use it in his subsequent research, and opinions from the industry were therefore essential. All of the interviewees agreed that the user-centred design concept could be very important to the design industry in the future. They believed the concept could help them develop new products that better fulfilled their users' needs.

However, when asked how user-centred design could be implemented in their daily design work, four of them (C, D, G, H) felt that the characters of their designers

were very similar to those of their end users. Consequently, they could just carry out user research on themselves, which is very different to the spirit of the user-centred design approach. Two of the interviewees (A and F) were shoe designers, and believed they could just use standard sizes to make every kind of shoe. Another two (E and K) believed that design experience is the most important element of a successful design.

Six interviewees, who worked as electric consumer product designers, had similar opinions about the industry. They thought the products they designed were very similar, and they could use their experience to design a new product, or just follow market trends to design a ”copycat” product.

In general, most of the interviewees agreed with the concept of user-centred design, and believed it could help them understand their users. However, the real situation is another story. The designers did not fully understand the spirit of the concept. They thought that because they were similar to the end user, they could function as proxies for them and use their own experiences to design products. Since designers usually have more knowledge about products and materials than the end user, their respective experiences could actually diverge significantly.

3. Empathic design

The researcher also asked the interviewees about empathic design. Since most designers in Taiwan have never heard of it, the researcher presented a short introduction as an example before asking them for their opinion of the concept.

Seven of the interviewees were interested by the concept and method, and were willing to try it. They thought it could give them the chance to become users, and bring some new ideas to their designs. Five, on the other hand, thought that the personal characteristics of their designers were very similar to those of their users, making it unnecessary to simulate the latters' activities. Some of them believed that experience and personal talent were more important than research.

They were then asked whether, if they were designing products for people with disabilities, they thought the method would be helpful? All agreed that it would be very useful to aid designers in understanding the differences between them and people with disabilities. If they had the chance to design for such a person, they would do so.

However, ten of them indicated that their design work entailed great time pressures, making it impossible for them to carry out user research. Moreover, some of them believed their team leaders would not allow them to spend time to perform this kind of activity, as timeframes and budgets are often the most important concerns when promoting a design method.

When discussing the problems entailed in promoting the empathic design concept, the predominance of the OEM and ODM business types is the main reason why Taiwanese companies think that user research is not essential. OEM companies only make products for their clients, and companies do not require their designers

to be creative. The main issue they are concerned with is how to reduce costs and create more benefits. ODM companies do have embedded design teams, and their designers are encouraged to develop their creativity. However, their clients often want to make ”copycat” products, and ODM companies only need to make small changes to existing products for their clients. Therefore, they felt user research to be unnecessary.

The education system in Taiwan as it concerns design is also an important issue. Only one in twelve of the interviewees had heard of the design concept, and he only learned about it from the Internet after his graduation.

All interviewees had graduated with design majors. They rarely had the opportunity to learn about new concepts in design user research, and universities tend to teach students how rather than why to make products. Very often, Taiwanese design students have excellent computer skills that enable them to use design systems and construct prototypes. However, if they had more opportunity to understand their users through research, their prospects in the industry could be improved.

The survey revealed some important points. Firstly, the method of discovering users’ requirements is very much related to experience: senior designers mostly use more diverse methods to conduct their user research when compared with their younger counterparts. Secondly, although some of them merely researched competitor products in order to decide which elements to add to their designs, they all believed that the user-centred design concept could be very important to the

industry. However, some of the participants still believed that they were very similar to their users, so they could just use their personal experiences as proxies for those of their users, thus obviating the need for user research.

The type of industry in question could be a main reason for not performing user research, since clients of OEM and ODM companies often only want products that follow competitors' examples; design company owners are therefore reluctant to spend time and money on user research.

3.3 Pilot Survey for Disabled Participants

3.3.1 Introduction

The aim of this survey is to understand how people with disabilities use AT and the environments in which they do so. Questions concerning AT usage include what AT they used, why they chose it, how it worked and what they felt about it. The environmental research includes questions regarding where the AT was used, the characteristics of size and space, and how these affected the AT and its user.

3.3.2 Participant Selection

The researcher needed to identify what conditions were "appropriate" for participant selection, as this research needs to represent real situations for people with disabilities and their AT. Firstly, the participants had to display obvious symptoms of disability. Secondly, the participants required at least ten years in a stable condition and should have been using more than one type of AT in order for the research to

benefit from the greatest amount of AT user experience. Thirdly, the participants must have been adult and healthy enough to take part in the interview process.

To provide a greater range of participants, the researcher contacted the Spinal Cord Injury Association in Taichung City, Yunlin County, and the Eaglefly team[10] . Eight participants were chosen from the members of those organisations, all of whom fulfilled the above requirements.

The researcher telephoned and emailed the eight selected participants in February 2009, and five responded. The researcher arranged a time in March 2009 to conduct the interviews and observations.

3.3.3 Survey Execution

The researcher used a digital recorder to record the interviews with the participants' consent. The interview was then transcribed.

A digital camera was used to record the environment; the researcher only took pictures after obtaining each participant's approval. If the participant had a job, their working environment and any ATs they used were also photographed.

The software Nvivo was used to analyse the collected data. Text from interview records was separated into sentences and analysed in groups according to

[10] The Eaglefly team: founded by Dr. Chu in 2001, it is the biggest spinal injury patients work group. The team is designed to help spinally injured patients to work at home. Team members are specialists in web design, and win many web design award in Taiwan.

meaning.

Detailed information relating to the participants is listed in Appendix A.

3.3.4 Questions and Observation

1. Interview

The interview SOP was separated into four parts. The first part included basic information relating to the participants, including age, gender, education, occupation and history of symptoms. The researcher also sought information regarding their economic conditions.

The second part, regarding their use of AT, included questions regarding:

- how they chose that particular AT
- who suggested it
- where they obtained it
- how they felt about it

The third part included questions about AT that they had abandoned:

- what kind of AT they abandoned
- why they abandoned it
- why they initially bought it

The fourth part was used to obtain a wish list for their AT. The researcher asked them what kind of equipment or service they would like to have in the future.

The interview used visual and digital audio media to record the interviews before transcription.

2. Observation

Observations were of three elements: the AT they currently used, the space where they used it, and whether they did so for more than five minutes. If the interviewee was in employment, the researcher also observed the workplace.

3.3.5 Data Analysis

The researcher collected data from the five participants in March 2009. One of the participants had symptoms of polio, and the other four had various levels of spinal injury. For safety's sake, the participants' caregivers stayed with them during the interviews. The researcher interviewed them himself, face to face. The participant with a communication problem wrote down his answers which were then spoken by his mother, who is also his caregiver.

In order to observe the spaces in which the AT was being used, the observation took place in the homes of the participants. Since some of their workplaces were elsewhere, those locations were also observed and recorded.

Due to the fact that the participants needed to stay in good physical condition, the

interviews were mostly conducted during the day. Only one of the participants worked at night, so the researcher interviewed him during the day and observed his workplace at night.

In total, the researcher interviewed five people and reviewed 17 currently used and and 11 abandoned ATs.

Table 3: Currently Used and Abandoned ATs

Interviewee	No.1	No.2	No.3	No.4	No.5	Total
Currently used AT	5	4	2	3	3	17
Abandoned AT	3	3	1	3	1	13

When asked where they obtained their ATs, the researcher found that almost all of the interviewees had designed their own. Even though one of them no longer used his self-designed AT, he had used it beforehand.

Table 4: Where Users Obtained their AT

Interviewee	No.1	No.2	No.3	No.4	No.5	
Self Designed	★	★	★	★		4
Bought from manufacturer	★	★	★	★	★	5

Non-disabled people usually do not have enough knowledge and experience to purchase AT. Advisors and opinion leaders thus play a very important role in the AT buying process. The present researcher has found that these advisors were often occupational therapists (OT) and suppliers of AT to the user. Some friends had often become opinion leaders.

In theory, the OT is the most important person when purchasing AT. They are trained medical professionals with a good knowledge of AT, and can give users a

better and more reliable service than anyone else. However, the interviewees would rather trust their friends and AT vendors. Since vendors are the people who most frequently visit users engaged in purchasing their products, users have no other way to obtain good AT. Additionally, as healthy people find it hard to understand users' difficulties, the latter are more likely to believe their friends who have similar disabilities to them.

Table 5: Advisors in the AT Buying Process

Interviewee	No.1	No.2	No.3	No.4	No.5	
Seller	★	★	★	★	★	5
Friends	★	★	★	★	★	5
Occupational Therapist		★	★	★		3
Designed by himself	★		★			2

The researcher found that the most common reasons for the abandonment of AT were that the technology made them feel uncomfortable when they used it, or that it was not suitable for the environment in which they were using it. It seems that the first problem could be solved by trials long enough to allow potential users to determine whether they could be comfortable with the AT after some time. None of the user respondents were given trials of sufficient length for this purpose.

The second problem regarding AT was its unsuitability for the environment. This mostly applied to some of the bigger AT facilities such as body hoists. This normally required a wide space, but Taiwanese houses are not usually big enough to mount such equipment securely, which created problems. If AT specialists could visit users' houses and make simple measurements, this problem could have been resolved.

Table 6: Reasons for Abandonment of AT

Interviewee	No.1	No.2	No.3	No.4	No.5	Total
Felt uncomfortable		★		★	★	3
Unsuitable for the environment	★	★	★			3
Not functional				★		1
Replaced	★					1
Symptoms disappeared						

The researcher was curious as to why the interviewees were more likely to use their own self-designed AT in their daily life rather than an off-the-shelf equivalent. The answers showed that this was mostly because mass-produced AT was not suitable for users' physical conditions and environments. The truism that no two people are alike applies as much to their symptoms as to other aspects of their personalities. Equally, each living space has its peculiarities. It is therefore very difficult for mass-produced AT to fit the individual needs of each user.

Table 7: Reasons for Using Self-designed AT

Interviewee	No.1	No.2	No.3	No.4	No.5	Total
It is unsuitable for physical condition	★	★		★		3
It is unsuitable for environment	★	★		★		3
It is too expensive		★	★		★	3
The mass-produced alternative is no better than a self-designed product	★					1

Finally, the researcher asked the interviewees to make a wish list for how they would have liked their daily lives to be improved. As shown in Table 8, it was very obvious that most of them wished they could have more of a barrier-free life. Barrier-free designs in Taiwan are not very thorough, although legislation now

states that every public building must be of a barrier-free design. This requirement is often honoured more in the breach than the observance. Shops and motorcycles often occupy the sidewalks, road surfaces are normally rough, and even slopes designed for wheelchairs are too steep to be climbed by a manual wheelchair.

The second popular wish was for a well-designed computer. Although they may have lost their physical mobility, they could open up new worlds for themselves by electronic means. Many of them could also use a computer to work at home. However, the control interface of a normal computer is not designed for people with disabilities. Even though there are many existing ATs designed to facilitate computer use, they often demand more time when inputting data than conventional machines. This is why many of the interviewees wished for a well-designed computer that would allow them to feel free in the virtual world.

Table 8: Interviewees' Wish lists

Interviewee	No.1	No.2	No.3	No.4	No.5	Total
Barrier-free life	★	★	★		★	4
Well-designed computer		★		★		2
Well-designed mobility AT	★					1
Well-designed work environment			★			1
Well-designed furniture					★	1

3.4 Summary

In this survey the researcher interviewed five people and reviewed 17 currently used and 11 abandoned ATs. Some significant findings on the survey should be noted:

1. The most common reasons for the abandonment of AT were that the technology made them feel uncomfortable when they used it (60 per cent) and that it was not suitable for the environment they were using it in (60 per cent).

2. 80 per cent of the interviewees had designed and produced the AT in question for themselves. When discussing their reasons for doing this, most of them indicated that they were highly unsatisfied with the AT they used, and believed that no one could understand their requirements better than themselves, meaning they were best suited to producing suitable AT for their own needs.

3. Many interviewees indicated that trials in their AT adoption process were often too short to allow them to feel the discomfort that would only arise after a certain amount of time, and the environmental conditions were very different to those in which they were actually to use the AT; under these conditions, the trials became meaningless.

Chapter 4

Empathy Tool Model Development

4.1 Introduction

To understand the requirements of people who have disabilities, empathic design constitutes a concept that uses observation, simulation and role-play techniques to allow the designer to step into, explore and experience a person's life (McDonagh and Thomas 2010). Through this process the designer can gain a better understanding of the user, and thereby contribute to the design concept.

The technique of stepping into a user's life often requires an empathy tool to allow designers to experience the user's physical and environmental sensations. In some laboratory studies the researchers simply used thick gloves to simulate the weakness of the hand grasp of elderly people, or dark glasses to simulate blindness. The substantial financial support some research organisations receive from industry allows them to build complicated suits that can simulate the physical situations of elderly people in order to inspire industrial designers.

Although most of these studies achieve some level of success, most of them do not involve a particular subject, and the simulations only roughly mimic the symptoms of a wide range of people. However, when adopted in real AT design, the situations are different.

Just as Norman (1993) indicates, there is no such thing as an average person, nor

is there any typical disability (Kintsch and De Paula 2002). Each disabled person has their own set of symptoms; some are affected by the same disease or the same areas of injury, or they have different degrees of disability. In addition, the environments in which they live and the AT they use are many and varied. Therefore, empathic AT design research for people who have disabilities should be correlated with a particular subject from the outset.

Moreover, the empathy tool plays a very important role in the empathic process. It is the main means by which designers can step into the life of the subject and then back into the role of designer. An appropriate empathy tool could allow the designer access to the details of a user's life, but an incorrect one may lead the user to false conclusions. A design model that results in the construction of a suitable empathy tool is therefore essential.

However, no design model for empathy tools exists in the literature reviewed in Chapter 2, especially in AT design for job accommodation. The aim of this chapter is therefore to build an empathy tool model for designers for this purpose. The design model will consider the designers' characteristics, the subjects' abilities and disabilities and their job requirements, and will then use these factors to determine the difficulties the subject experiences in carrying out their job, as well as the differences between the designer users and the subject.

4.2 The Empathy Tool Design Model

Based on pilot surveys conducted with both designers and participants, and combined with the literature review, the present researcher designed a model for the design of the job accommodation empathy tool. The structure of the design model is illustrated in Fig.6

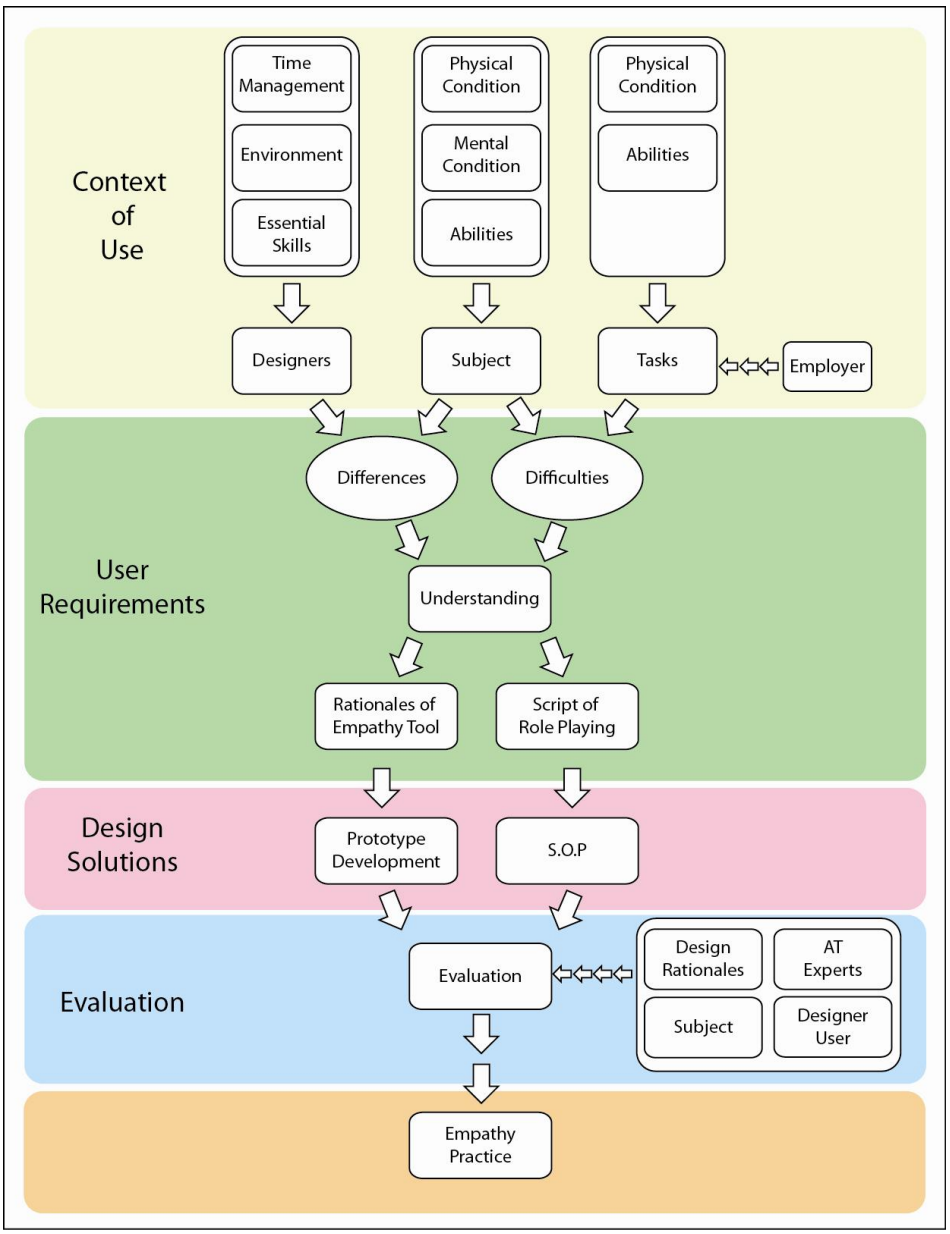


Fig. 6: The Empathy Tool Design Model

Since the design model is developed from the user-centred design concept, the activities involved in the main body of the model can be divided into four stages: specifying the context of use, specifying the users' requirements, producing design solutions and conducting an evaluation.

4.2.1 Context of Use

In this stage, the tool's designer investigates its three major elements: the subject, the designer user, and the subject's task.

it is most important to research the subject. According to the literature review, the subject should be individually selected, as every disabled subject's disabilities are different. Their physical condition should be considered. For example, some types of disability do not allow the subject to work continuously for long periods of time, which necessitates good time management, and some disabled people need electrical equipment for their wellbeing, so that they have to chose work environments with electrical sockets

Their mental conditions must also be considered in the design process. Some disabilities arise from mental illness, some disabled people need assistants to help them at work, and others need to rest after a short period of time. In such cases subjects' working time needs to be rearranged, and assistants' working hours also need to be considered.

A very important principle in job accommodation is that designers should focus on

the subject's abilities, rather than their disabilities; therefore, the subject's abilities, as they relate to their tasks, must also be evaluated. These abilities include physical mobility, level of education and communication skills.

It is also essential to research the working time, tasks and working environment involved in any given job. The researcher can use task analysis to ascertain the related tasks. This technique uses recording equipment to record every movement involved in doing the job, as well as the work environment and the interaction between subject and colleagues or clients. This data is then analysed and combined with the subject's abilities in order to discern the difficulties the subject experiences in that particular job.

Successful job accommodation must be conducted in consultation with the subjects' employers, because they control the budgets for such projects, and all changes in tool use, facilities, environment and time management must be negotiated with them. Designer, subject and employer must all discover the best way of making minimal changes while gaining the maximum benefit.

Designers are the end users of the empathy tool. Unlike the subject the designer is not an individual user, and the tool's design should allow the greatest number of designers to use it. The tool's function is to allow designers to understand their disabled clients. Identifying the differences between designer and subject is therefore crucial. In order to define these differences, the physical characteristics and abilities of the designer should be determined.

4.2.2 User Requirements

The goal at this stage is to find out the difficulties encountered by subjects in their jobs, as well as the differences between subject and designer. The latter can then use these to understand the subject. This understanding is then combined with the designer's professional knowledge to create design rationales for the empathy tool.

The rationale behind the design is twofold. Firstly, the empathy tool is designed to simulate the subject's physical conditions. The normal method of simulation is to limit the functionality of specific parts of the designer's body. As the tool is meant to be used by product designers, the UD concept could be employed to develop the design's rationale.

However, if empathy practice is limited only by the designer's physical functions, users may not experience the difficulties as they do not know what to look for. This is the second strand of the rationale: practice with the empathy tool should be combined with a scenario that directs the users to the same activities as those performed by the subject. These activities use the data collected from the task analysis process described in the previous stage.

4.2.3 Producing Design Solutions

After the design rationale is developed, a prototype of the empathy tool must be produced using the designer's professional knowledge of material selection, production processes and design principles.

The structure of the scenario is also produced in this stage. The empathy tool's designer needs to use task analysis to determine those activities that pose difficulties for the subject, list them in the scenario and produce a standard operation procedure (SOP).

4.2.4 Evaluation

The prototype is then evaluated by wearing the empathy tool and practising the scenario. The design rationale functions as a check list for the evaluation. Moreover, the subject, designer users, and AT experts will be invited to evaluate the prototype.

If the prototype passes the evaluation process, it can be used by designers in empathic practice. If it fails, however, the concept is reviewed and a new one developed to generate a new design rationale for a new prototype. This process is repeated until a satisfactory tool is produced.

4.3 Summary

In this chapter, the design model was constructed based on the results of literature review and on AT user and designer interviews. The model follows the process of user-centred design, and consisted of four stages: context of use, user requirements, design solutions and evaluation. The researcher considered the difficulties encountered by subjects in their jobs, as well as the differences between designers and subjects, to obtain the necessary understanding of both. This understanding was then used to inform the rationale for the empathy tool, and a

role play scripted to produce it. Finally the design rationale, subject, AT experts and designers were invited to join the evaluation process so as to enable the empathy tool to fully mimic the physical circumstances of subjects in their work environments.

Chapter 5

Empathy Tool Development

5.1 Introduction

The function of the empathy tool is to help product designers understand a particular subject who has disabilities. This understanding will allow designers to focus on discovering problems in the necessary accommodations to be made in the subject's workplace.

The researcher selected a spinally injured lottery seller in Taiwan as the subject of his research. In order to obtain a better understanding of the subject, he interviewed him and his caregiver and recorded the subject's work processes and environment. He then analysed the collected data to identify the difficulties the subject faced in his job accommodation.

The differences between subjects and designers without disabilities are also important. In order to compare these differences, the researcher identified the subject's symptoms, harvested data concerning the physical characteristics of designers in Taiwan from the database, and compared the abilities of the two.

The purpose of this comparison and task analysis was to develop the rationale for the empathy tool design, a rationale that consisted of two strands: empathy tool design and the scenario surrounding the empathy tool experiment. Without a proper scenario, the designer users would find it hard to experience the difficulties

faced by the subject.

The researcher then produced the empathy tool, which consisted of five parts: waist, left knee, right knee, left ankle and right ankle. The empathy tool's purpose is effected by using rigid material to bend each of the aforementioned body parts by ninety degrees. The rigid material prevents designers moving their limbs easily, and the ninety degree posture keeps them in a position in which they can use their limbs and waist to stand only with difficulty.

The tool was constructed from PET[11] boards and strips, and it was produced using computer-aided design[12] (CAD) software and a plastic workshop. Although there were some errors during the production process, the final product fulfilled all the design rationale's requirements.

The empathy tool passed the evaluation process and was used by designers in experiments, as described in the next chapter.

5.2 The Descriptions of the Subject

Both the job accommodation process and the adoption of AT should involve customised designs. The designer of an empathy tool should therefore find a

[11] Polyethylene Terephthalate (PET): is a thermoplastic polymer resin of the polyester family widely used in the manufacture of beverage and food containers.

[12] Computer-aided Design (CAD): is the use of computers to assist in creation or modification of a design.

proper subject before the practice starts.

5.2.1 Subject Selection

To find a suitable subject for this research, the researcher selected a suitable subject for this research according to the following criteria:

- The subject should be a person with a disability.
- The subject should be in, or be preparing for, employment.
- The subject's health should be stable enough for them to carry out the research.
- The subject should be willing to participate in the research.

The researcher looked for a suitable subject from among Taiwanese associations and government organisations. They suggested he select a lottery salesperson because lottery selling requires a special permit for which only vulnerable people with disabilities, aboriginal people and single parents can apply.

Many disabled people, especially those with limb injuries, have performed this job for a long time. There were 26,843 disabled lottery sellers in 2003 (Lin 2003). However, the lottery company does not provide enough support for their special needs, and sellers often face difficulties resulting from the lack of appropriate equipment.

Fig.7: The Subject, Mr. H

Many lottery sellers are members of the Spinal Injured Society. The researcher made contact with the Society in Taichung City, Taiwan, and they society suggested three of their members to him. After considering their physical condition and sales location, the researcher chose a typical lottery seller, Mr. H, to be the subject of this research (Fig.7).

5.2.2 The Subject's Symptoms and Characteristics

The researcher visited the subject five times before starting to construct the empathy tool. In order to collect detailed information on the subject, he visited both the subject's living and working spaces. Due to the subject's moderate conversational difficulties, the researcher interviewed him together with his mother (who was also his caregiver) during his visits.

The subject, Mr. H, is a 28 year old male with a high school education. He has a T12 level spinal injury from a car accident he was involved in when he was 10. He also has congenital moderate conversational difficulties. He has worked as a lottery seller since the Taiwanese government allowed private companies to sell lottery tickets in 1999.

His T12 level spinal injury means that the twelfth thoracic vertebrae is injured, reducing or even eliminating altogether the brain's ability to communicate with the body below the chest (AQA Victoria 2012). Symptoms of spinal injury are not restricted to sufferers' nervous systems: spinal scoliosis often follows, after patients

lose muscle control, often suppressing and damaging the patient's inner organs and thereby causing more physical problems (Colette and Dijkers 2001).

Mr. H has lost the use of his lower limbs and cannot use his abdominal muscles to adjust his body when he is sitting in a wheelchair. To move from his wheelchair is very hard for him. His lower body paralysis means that he has no sensation of needing to urinate. This has caused kidney problems, and consequently he needs to undergo dialysis twice a week. He has congenital moderate conversational difficulties, although he can pronounce some words and is able to communicate with his mother. His customers find it very difficult to understand his speech.

In an interview with Mr. H, the researcher found his financial situation to be worse than that of the average Taiwanese family. He lives with his mother in an apartment near the city centre and uses an electric wheelchair both at home and in his work. He also uses a hearing aid to improve his hearing ability and, due to his communication difficulties, he must write in a notebook to communicate with his clients.

When asked about the kind of AT he would like to use in his work, he considered the device he currently used to be too heavy and not organised properly. What he wanted was a lightweight device, easy to install and carry and, most importantly, affordable.

5.2.3 Task Analysis

The task of lottery selling is not very complicated for a person without a disability. However, when it is being undertaken by a person with multiple disabilities it becomes very difficult. Therefore, before the researcher started to design the empathy tool, it was necessary to research the requirements of the task, the subject's working environment, the employer's opinions and the time management required by the task, so that he could properly analyse the task and make his analysis more realistic.

5.2.4 Requirements of Task

Selling lottery tickets requires basic calculation and communication abilities. The seller needs to sell the lottery tickets, promote the lottery, explain the playing method and answer clients' questions. Since most sellers cannot sell tickets from their own homes, they must have the mobility to travel to a workplace.

5.2.5 Employer's Opinions

In the majority of job accommodation cases, subjects are hired by the employer, whose opinions must therefore be considered by designers. Much research has revealed budget, the effect of the working process and the effect of the subject's colleagues to be employer's most pressing concerns.

Designers, employers and subjects should, however, seek the best solutions for job accommodation together. Designers should strive to attain the greatest efficiency at the lowest cost. Employers should concentrate on the end result of the job

accommodation, rather than on the way that job has traditionally been performed (Perterson and Pree 1996). Finally, subjects should try to perform their jobs to the best of their abilities.

Subjects and employers should look for “win win” strategies. Most important is cooperation between all three participants in order to find a reasonable job accommodation (Chou et al. 1996). The word “reasonable” indicates that the cost of changes to the job process should be less than the benefits accruing from them, benefiting employers while providing subjects with gainful employment in that industry without damaging their physical or mental health (USDOJ 2002).

The lottery sellers are self-employed, which means that the present subject had to take responsibility for himself and pay the cost of his AT. Affordability was thus a serious consideration for him.

5.2.6 Working Environment

The subject conducted his business on the sidewalk by a post office about 200 metres from his house. As Taiwanese people are often busy working until late afternoon, the post office is open until 9:30pm, and the subject worked there from 6:30pm to 9:00pm daily.

His reasons for choosing this location and working time related to his physical condition, which was not suitable for daytime work because the sun would have been too bright and the temperature too high – up to 38 degrees Celsius in the

summer. Moreover his physical difficulties meant that he could not work too far from his caregiver in case he felt uncomfortable. He therefore needed a location that was near his house. The opening times of, and distance to, the post office proved quite suitable for his requirements.

The post office was not ideal, however. Its regulations prohibited him from working under its roof, so he could not work in even light rain. The sidewalk was dark at night, and the instructions were printed on the lottery tickets in very small type, meaning that his customers had difficulty reading them. The sidewalk location also meant that he could not store anything there; every day he therefore had to install his work station at the beginning of his shift and dismantle it when he finished.

Working at night is more risky than daytime work: in recent years robbers have often targeted disabled lottery sellers (Chun 2010 and TTV 2010). The fact that spinally injured lottery sellers are more vulnerable than other people, combined with the subject's late working hours, made robbery a fairly likely occurrence for the subject.

Safety issues were also very important him, especially in view of his nocturnal working hours. Barrier-free environments are far from universal in Taiwan. Vehicles and pedestrians often mix, posing problems for wheelchair users' view of road traffic, especially at night.

5.2.7 Tools

Unlike factory or office workers, the subject had no permanent space to set up his workstation, which he had to install and dismantle daily. All the tools needed for his job were carried in his electric wheelchair, which were both his transportation and his workstation. This station included a wooden board, folding chair, small table lamp, computer bag, umbrella and big rubber band bound to the wooden board, as shown in Fig.8:

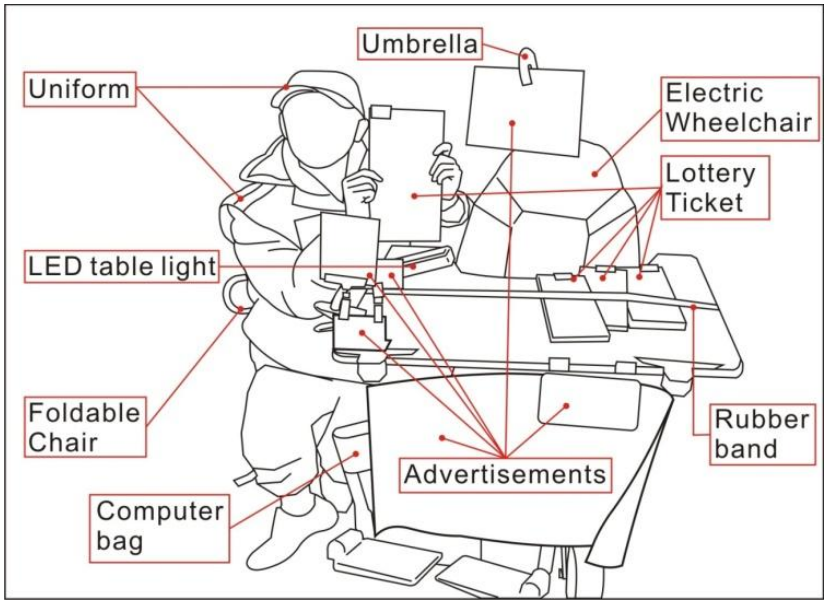


Fig.8: Subject's Workstation and Tools

The biggest piece of equipment in his station was the wooden board, which was 80cm wide by 50cm long and weighed about 3 kg. His uncle made it for him from an abandoned table. It straddled the armrests of the wheelchair, and all his lottery tickets and other tools were laid out on that board. The folding chair was necessary because the wooden board was too big for him to sit on the wheelchair while the wooden board rested on its armrests. The small LED table light was for the dark sidewalk environment which otherwise made it impossible for him and his

customers to check the lottery ticket numbers, as was necessary. The rubber band fixed the tickets to the board to prevent them flying away in the wind. The lottery company supplied him with the computer bag in which to keep his tickets and money.

5.2.8 Tasks

The tasks involved in his job were:

- *Installing the work station*

Normally he hung his wooden board and folding chair on the rear of the electric wheelchair while travelling from his home to his work location. Fig.9 shows the four steps involved in installing his workstation whenever he arrived at his work location.

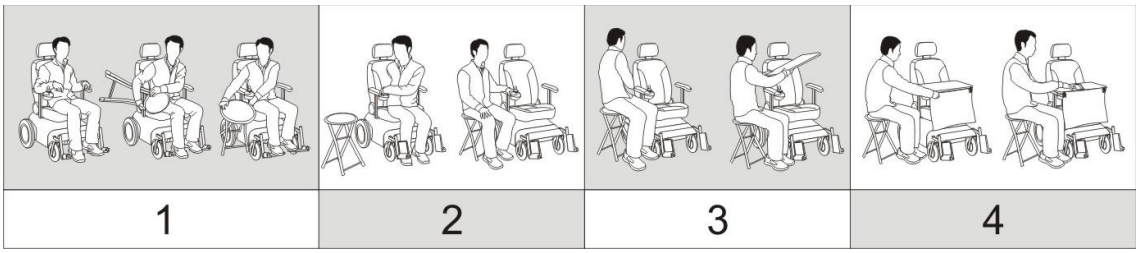


Fig.9: The Installation of the Workstation

There were four steps involved in installing his workstation. He first unloaded the folding chair and set it up beside the wheelchair. He then transferred from the wheelchair into the folding chair, took the wooden board from the rear of the wheelchair and installed it on the armrests, and finally set out his banner, installed the small LED table light, took his new lottery tickets out of his bag and used the rubber band to fix them to the wooden board.

- *The selling process*

The post office's late opening hours made it an ideal location for selling lottery tickets at night. In fact, it is the only night post office in Taichung City, which has a population of more than a million. There streets are therefore always crowded. Mr. H is the only lottery sales person in the area, and has been for ten years, so he has built up a loyal clientele. He has an average of seven customers per hour on weekdays, which is very good for a lottery seller. The processes of selling lottery tickets is described in Fig.10.

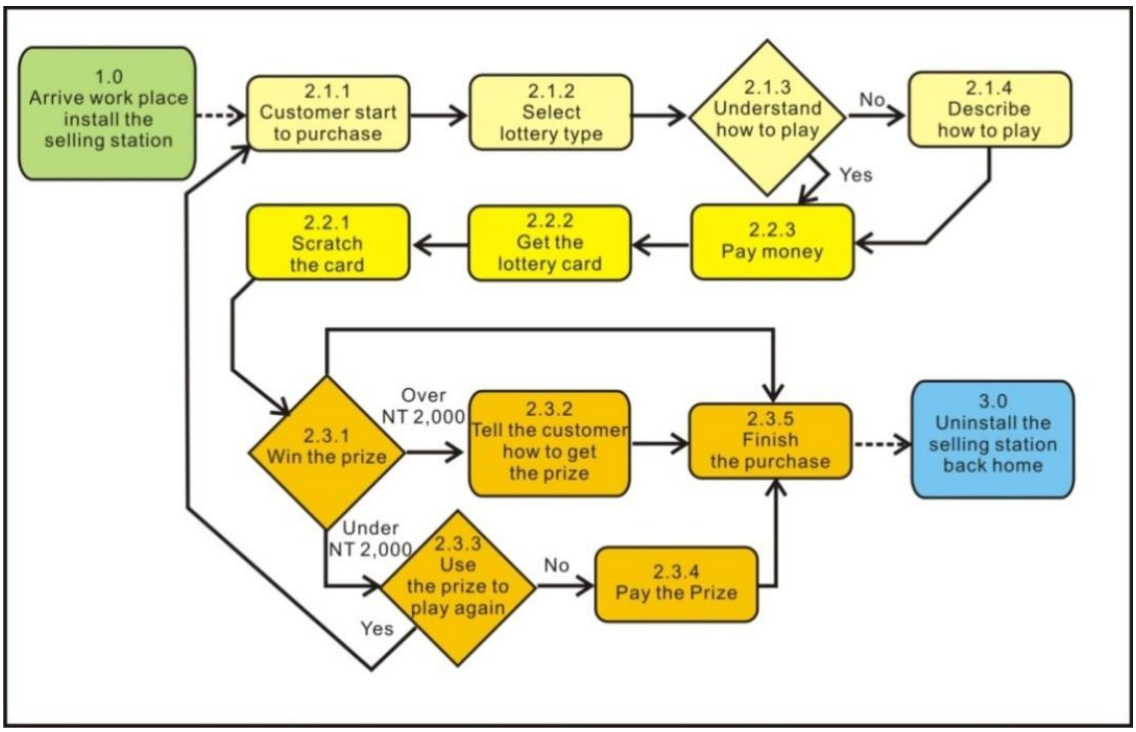


Fig.10: The Subject's Work Processes

- *Selecting the type of lottery*

The lottery company sells many types of lottery ticket. Each type has a different

playing method, size, layout and prize.

- *Do customers understand how to play?*

Since the lottery is divided into so many types, customers can only play it easily with regular experience. New customers are often unable to understand the playing method, and the description on the rear of the ticket is in very small print, which is not easy to read in a dark environment.

- *Describing how to play*

Since the lottery has various types, new customers often need some verbal instruction on how to play. Due to his speech problems, this is very difficult for Mr. H.

- *Collect Money*

The lottery in Taiwan has three prices: 50, 100, and 200 New Taiwanese Dollars (NTD). It is very easy for Mr. H to arrange his money, but not to secure it in an open environment.

- *Obtaining the lottery tickets*

Unlike elsewhere, customers in Taiwan prefer to choose not only the ticket type but also the ticket itself. They believe that good ticket numbers could bring them good luck , so they do not take the tickets in numerical order.

- *Scratching the card*

As with the lottery card customers in the UK, Taiwanese customers use coins, keys or other objects to scratch their lottery cards. However, Mr. H's station is located in the street, and customers find it difficult to find somewhere to place the card in order to scratch it.

- *Winning a prize*

When a lottery scratch card prize appears, customers can find out how much they have won. Prizes are from NTD 50 to NTD 2 million, according to the rules and depending on type. If the prize is under NTD2000, the customer can obtain it from the seller. In these cases, the customer normally opts to use the prize money to play again.

- *Informing customers how to claim their prizes*

If the customer wins a prize of more than NTD2000, the seller must tell them at which bank they can exchange their ticket for money. This is also difficult for Mr. H.

- *Using the prize to play again or paying the prize in cash*

If the customer wins a prize under NTD2000, he could either use the prize to play again or exchange it for cash from the seller.

- *Completing the purchase*

When the client completes the purchase process, the subject prepares for next client.

- *Dismantling the workstation*

Each time Mr. H finished conducting his business, he had to collect all his tools, load them onto the back of his electric wheelchair and take them back home. This was a four-step process, as shown in Fig.11.

He collected up the unsold lottery tickets, put the LED table light into his bag and took off the rubber band. He then removed the wooden board from the armrests and attached it to the rear of the electric wheelchair. He transferred from the folding chair to his electric wheelchair. Finally, he collapsed the folding chair and bound it,

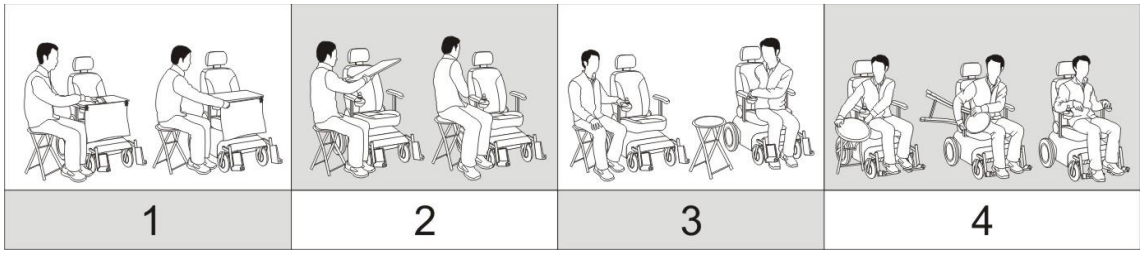


Fig.11: Dismantling the Workstation

together with the wooden board, to the rear of the wheelchair using the rubber band. He then rode his wheelchair home.

5.3 Designers

The goal of this empathy tool is to help ordinary designers understand the real needs of subjects in their jobs in order to make appropriate accommodations. The tool is intended to be worn by designers in the course of their empathic design research. The empathy tool should therefore consider designers' body sizes and degrees of mobility, and should simulate the subject's symptoms.

The author ascertained the physical characteristics of the average Taiwanese designer using the Taiwanese labourer body statistics database, which incorporates data from 1996 collected by the Institute of Occupational Safety and Health (IOSH) in Taiwan. 1,200 samples from 735 males and 465 females aged from 18 to 65 years were collected to construct the database, which provides users with 266 static and 42 movement measurements. It is widely used in designing workspaces in Taiwan (IOSH 2008).

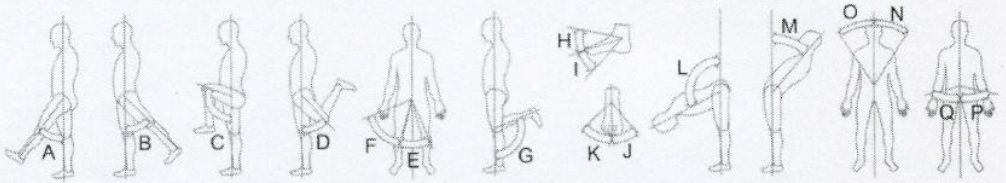
Although the database does not contain statistics relating to designers in particular, it provided the researcher with those for the average Taiwanese labourer. It is important to note in this context that there are no significant differences between the physical characteristics of healthy labourers and those of designers.

The average age of young Taiwanese design students who have graduated from university and started work as designers is about 22. They normally work in this industry until about 40, before most of them transfer into design management or other managerial positions. This was why the present researcher chose those ages as the range for his research.

The IOSH database contained 724 male and female samples within this range, which the researcher further condensed by focusing on injuries to the lower limbs and waist. The author was able to use statistical data relating to movement and size to consider the size of the empathy tool.

The statistical results collected by the researcher are shown in Tables 9 and 10. Table 9 gave a clear idea of the physical movements possible to people without disabilities, so that the author was able to define the required movements.

Table 9: The Body Movement Data for the Age Range 22-40

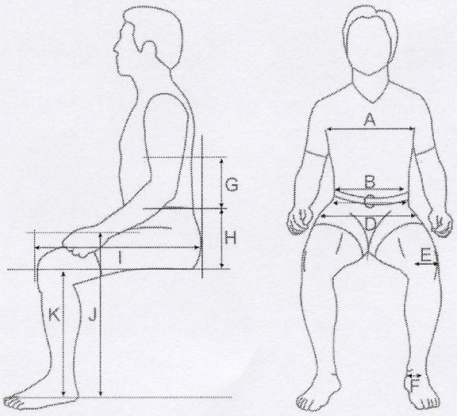


	Movement	Average	Standard deviation	5%	50%	95%
A	Hip Flexion	66.07	10.36	49.03	66.07	83.11
B	Hip Hyperextension	41.01	8.34	27.29	41.01	54.74
C	Hip Flexion-Supine	102.59	7.76	86.53	102.59	118.65
D	Hip Flexion-Prone	36.24	9.72	20.25	36.24	52.24
E	Hip Adduction	40.78	10.29	23.85	40.78	57.71
F	Hip Abduction	49.06	10.44	31.88	49.06	66.23
G	Knee Flexion	121.83	13.36	99.85	121.83	143.81
H	Ankle Dorsi-Flexion	36.74	7.13	25.01	36.74	48.48
I	Ankle Plantar-Flexion	25.28	7.81	12.43	25.28	38.12
J	Ankle Inversion	30.14	10.01	13.68	30.14	46.60
K	Ankle Eversion	19.77	6.62	8.87	19.77	30.66
L	Spine Forward Bending	118.18	15.15	93.26	118.18	143.11
M	Spine Backward Bending	38.93	13.51	16.72	38.93	61.15
N	Spine Lateral Bending Left	30.53	8.19	17.06	30.53	44.01
O	Spine Lateral Bending Right	31.60	8.65	17.37	31.60	45.84
P	Spine Rotation Left	33.05	9.08	18.11	33.05	47.99
Q	Spine Rotation Right	34.01	10.15	17.32	34.01	50.70
Population: 724, Age from 22 to 40						

For example the lower limb movements from A to J are precisely those that the subject could perform because his muscles in those areas had been incapacitated. When designing empathy tools, the designer's lower limbs had likewise to be rendered immobile. Mr. H still had some abilities as regards movements L and M, however, so the empathy tool also had to mimic these.

Table 10 gave the researcher a size guide for the empathy tool, whose purpose is to limit the movement of ankles, knees and waist, and which is used in a sitting posture. The dimensions of these body parts when one adopts such a posture are very important to the design of the empathy tool. The author used average dimensions in the tool's design.

Table 10: Bodily Dimension Data for the age range 22-40



	Distance	Average	Standard deviation	5%	50%	95%
A	Chest width in armpit	310.59	16.00	284.27	310.59	336.90
B	Lower chest width	276.92	22.07	240.61	276.92	313.23
C	Waist width	318.48	20.20	285.26	318.48	351.70
D	Hip width in sitting posture	336.11	31.60	284.14	336.11	388.09
E	Knee width	81.52	8.17	68.08	81.52	94.95
F	Ankle width	63.16	4.52	55.72	63.16	70.59
G	Lower chest to navel	190.05	20.92	155.65	190.05	224.46
H	Navel to hip	246.65	21.65	211.03	246.65	282.27
I	Front of knee to rear of hip	544.42	26.15	501.42	544.42	587.43
J	Upper knee to ground	497.14	25.35	455.47	497.17	538.87
K	Under knee to ground	395.79	17.84	366.45	395.79	425.13
Population: 724, Age from 22 to 40						

5.4 Differences and Difficulties

5.4.1 Comparison between Subject and Designer

The most obvious difference between a healthy designer and the subject is in their lower limbs. Due to his spinal injury in T12, the subject is unable to control his waist and lower limbs, both of which are being paralysed. This affects his mobility when he is working.

The second difference is his communication difficulties, which prevent him pronouncing words properly. Although he can lip read, he often needs pen and paper to communicate with his clients.

Since he has lost all sensation below his chest, and he often works outside for a long period of time, he also has problems with his kidneys. He needs kidney dialysis twice a week and cannot work far from his family. However, his work location has already been determined, and is almost perfect for his conditions. His kidney problems are therefore not much affected by his job, which is why the researcher did not take this factor into the consideration when designing the empathy tool.

5.4.2 Subject Difficulties when Performing Tasks

The task analysis for lottery selling revealed some aspects that posed difficulties for the subject. The findings of this analysis are shown in Fig.11, with the illustrations surrounded by red rectangles representing areas of greatest difficulty.

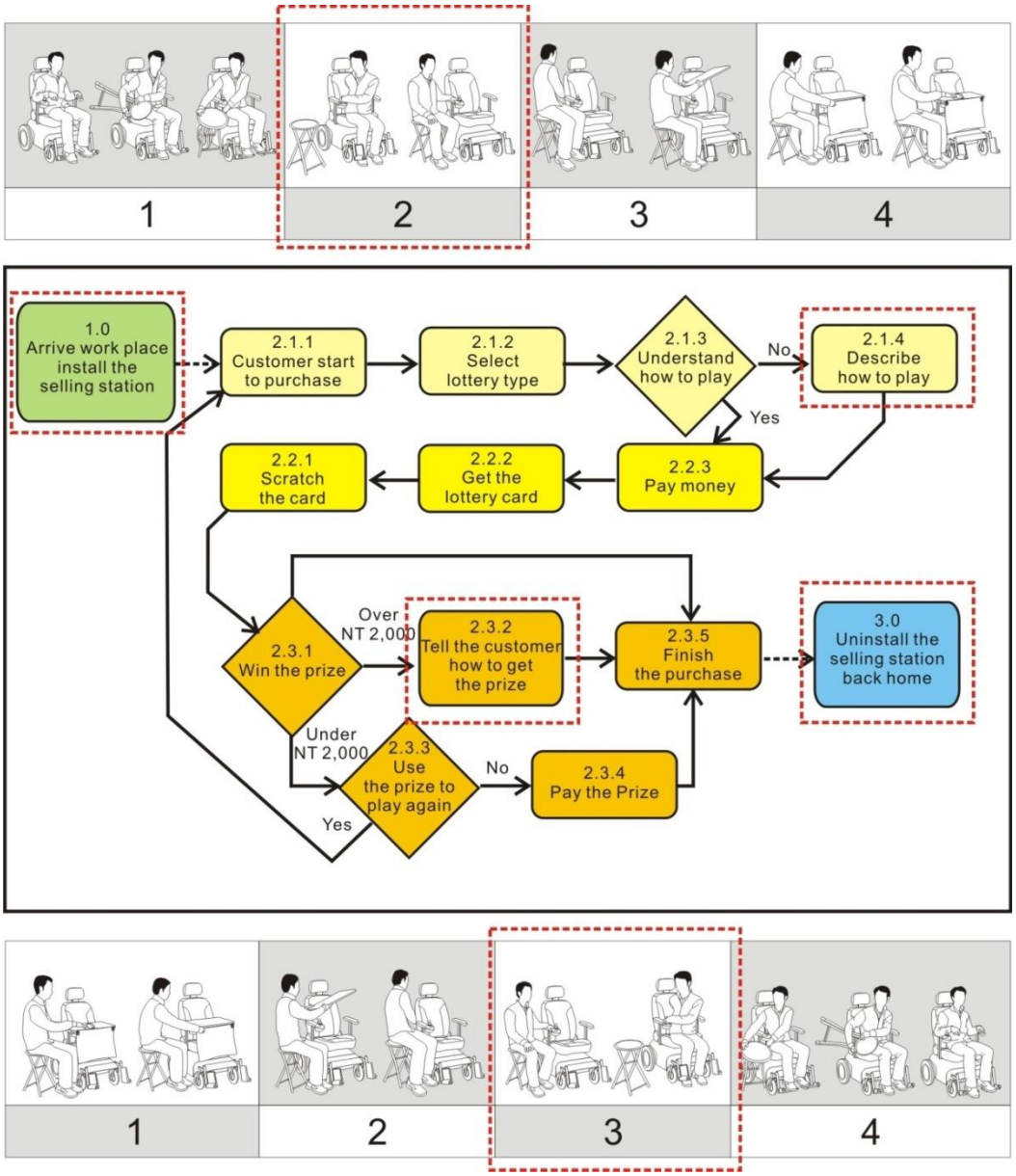


Fig. 12: The Difficult Elements of Each Task

1. *Getting to his workplace:* he needed his electric wheelchair all the time. Barrier-free buses are not common in Taiwan, so he could only work near his house.

2. *Transferring from the wheelchair to the folding chair and back again:* the electric

wheelchair's armrests are too short to support the table, so he needed to move from the wheelchair to the folding chair both before and after his shift. This was both very difficult and dangerous for him, as one small mistake could have caused him to fall, which would have been especially perilous in the light of his spinal injuries.

3. *Installing and dismantling his work station:* his spinal injuries had resulted in a loss of muscle strength in his waist and lower limbs, making it very difficult for him to sit securely in his folding chair. This presented a particular obstacle when he needed to install a heavy wooden table on the wheelchair. As it required him to change his barycentre to raise the table, this movement could easily have caused him to fall.

4. *Communicating with his customers:* his problem with communication was the most serious obstacle in his job. Although most of his clients were patient, they were often confused about how to play the lottery. There were several lottery ticket styles, each with its own playing method. However, the instructions on the lottery tickets were too small to read, especially in the dark, so the ability to explain how to play was essential.

5. *The environment:* although the place where the subject sold his lottery tickets was very good for business, it had many disadvantages. One of these was that the space was unsheltered, so when it rained he had to stop selling his tickets. The wind often caused the lottery tickets to blow away; of course, he could not

chase them.

5.5 Empathy Tool Development

5.5.1 The Rationale Behind Empathy Tool Design

The researcher used the results of the comparison and task analysis to understand the difficulties faced by the subject in his job, as well as the differences between him and designers. He then used these results to develop the rationale for the design of the empathy tool.

There are six strands to this rationale:

- A designer without disabilities should be able to use it.
- It should fit within the seating space occupied by a standard wheelchair.
- It should limit the designer's lower limb activity.
- It should limit the designer's waist activity.
- Its construction should be sturdy enough to withstand the physical strength of a person without disabilities.
- It should not harm users.

5.5.2 The Rationale of the Scenario Design

An empathy tool is designed to limit designers' movements so as to recreate the subject's conditions. However, the participants' movements only have meaning in a particular environment when undertaking specific activities. It is important for the designers to use the tool for the same purposes as the subject in order to discover the difficulties faced by the latter. An empathy tool design should therefore include

a script to guide the user what to do and when to do it.

The environment in which the subject worked also strongly influenced his activities, so the script should also include a description of the physical setting. The light, related facilities and position should be presented to reflect the actual conditions. All the elements in the real environment should be simulated as much as possible, so the designer can feel, and thereby understand, their real impact as much as possible.

The rationale for this script is the focus on simulating the difficulties involved, and the best way to mimic the subject's activities is to do everything in exactly the same way as him. However, time and budget are recurring problems for most research, which is why the researcher selected certain key activities that could affect the design and mimic the environment in which the subject worked.

The five strands of the script's rationale are:

- They should copy the key activities of the subject in his work.
- They should mimic the environment of the actual workplace.
- The order of activities should follow that outlined by the task analysis.
- The tools used in the simulation should be the same as those in the actual work situation.
- Every activity should be well recorded for further analysis.

5.6 Design of the Empathy Tool

The researcher began to design the empathy tool according to its rationale. He noted the differences between the subject on the one hand and designers on the other. The most obvious of these were the mobility and communication difficulties experienced by the former. Communication difficulties could be simulated by limiting the ability of the designer to communicate during role play. Simulating the paralyzed lower limbs was, however, more difficult. It can most accurately be mimicked by using medicines to paralyse the limbs. However, this is impossible to do for the purposes of simulation. The researcher had therefore to find another way to recreate this form of paralysis.

The first design the researcher thought of was to use a cloth bag to bend the designers' lower limbs. However, he found that – unlike the subject – they could still use their muscular strength to stand up and support their own body weight.

He then designed a new empathy tool, now using rigid material to keep the angle of the lower limbs the same as those of the subject. The rigid angle of the empathy tool could limit the muscle strength of the designer users, preventing them from standing up or changing position.

In addition, even though the empathy tool was designed to be used by non-disabled designers, some essential design principles should still be considered. The researcher employed the UD principle in the tool's design rationale. However, because the purpose of the empathy tool is to allow designers to experience the

same physical difficulties as does the subject, the former should remain sensitive while using the tool. Some of the principles included aspects necessary to UD, such as comfort, regardless of the ambient conditions. This is very difficult to achieve with an empathy tool design. The researcher tried to limit the users' discomfort.

The design is focused on the waist and lower limbs. It consists of five parts: waist, left knee and ankle, and right knee and ankle. The detailed AT design is as follows:

1. *The waist:*

The aim of this section is to limit the activity of hip flexion, hip hyperextension, hip flexion-supine, hip flexion-prone, hip adduction and hip abduction. It is designed not only to bend participants in the wheelchair itself, but also when they transfer from it to the folding chair. The waist section should prevent users from straightening into an upright position, and render them incapable of using their stomach muscles when standing up.

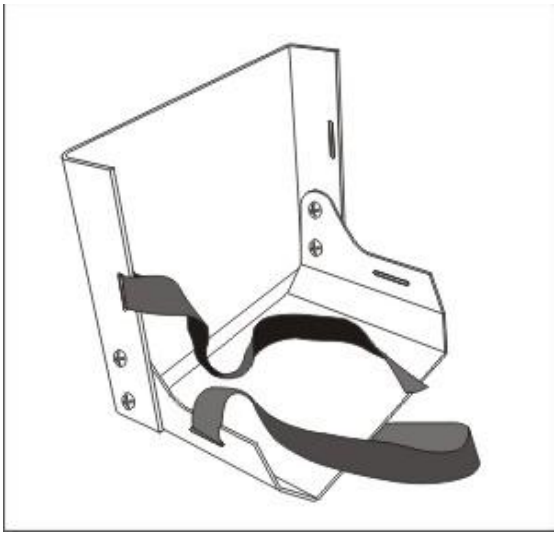


Fig.12: The Design of the Waist Section

The waist section is used in the wheelchair, so its width should be smaller than the distance between the two armrests of an ordinary wheelchair. As it is to be worn by a designer, it should fit the average Taiwanese waist.

To simulate the subject's physical condition, the height of the waist section is that of the T12 spinal vertebrae to the lower side of the hip while in a sitting posture. The depth of this is determined by the measurement from the rear of the hip to the centre of the average thigh. Because the author had to bring the empathy tool set when visiting the participants, it is designed to fold and be easily stored in a bag.

2. *Knee sections:*

The knee section is designed to control the degree to which participants can flex their knees. It is used to keep the user's knees bent at 90 degrees. Each part of it uses a foam sheet to cover the inside so as to make the user feel more comfortable and avoid slippage. It also has two straps to keep the thigh and calf bent at 90 degrees. The height is half the average calf length, and its depth is also half the average thigh length as determined by the IOSH.

Fig.13:The Design of the Knee Sections

3. *Ankle sections:*

The ankle sections are meant to limit the movement of the ankle dorsi-flexion, ankle plantar-flexion, ankle inversion and ankle eversion. They are designed to hold both feet rigid. Their height is half that of the average calf, their depth is from the heel to the base of the toes and their width is that of the the widest measurement in the IOSH database. The inside of the AT is also covered by a thick foam sheet to avoid slippage and to increase the user's comfort.

All the sections are show in Fig.16, together with their method of wear.

Fig.14: The Design of the Ankle Sections

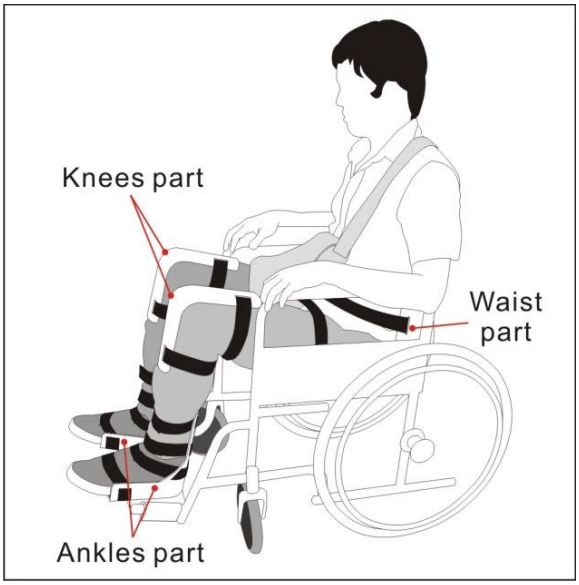


Fig.15: The Design of the Empathy Tool

5.7 Empathy Tool Production

The empathy tool was produced in a plastics workshop at De Montfort University in the UK. The researcher separated his design into components, and drew them

using CAD software. He then printed them at full size so that he could use them to cut the materials he needed.

The chosen material was 4mm Polyvinyl Chloride[13] (PVC). It is easy to process and has enough strength to withstand muscle use. Some similar empathy tool designers, such as the Nissan Technology Centre in Tokyo, use nylon clothes and a flexible steel structure to limit the activities of designer users, in a similar attempt to understand their elderly subjects (Worldcarfan.com 2008). However, those cases are different to the present research: most elderly people lose their muscle strength, whereas disabled people are paralysed because of problems with their nervous systems, rendering them incapable of controlling their muscles. The researcher therefore used the stiffer material of PVC to simulate the subject's disabilities.

The researcher used a 40mm wide, 1 mm thick nylon strap to restrict participants' activities. According to the manufacturer's documentation this strap can withstand 2,200 pounds in weight, meaning that it has enough strength to resist a user's muscular flexion. Velcro and a click-lock system are also used to connect the two straps, providing a strong connection. The straps' lengths are adjustable, allowing the empathy tool to be worn by several designers.

The details of the construction process were as follows:

[13] **Polyvinyl chloride (PVC): a kind of plastic of a durable, cheap and easily worked character.**

Waist.

1. A full size graphic was used to cut the outline of the required PVC board.
2. A mill was used to drill two 45mm-long x 6mm-wide holes for the straps, and four 5mm diameter holes for the screws in each part of the PVC board.
3. A machine was used to heat the PVC board in an accurate line and bend it to 90 degrees.
4. The 40mm-wide nylon strap was cut to 600mm long and the click-lock system was attached.

Fig.16: The Waist Section

Knees:

1. A piece of wood was cut to make a wooden model base.
2. It was sanded down to the required shape.

Fig.17: The Knee Section

3. A vacuum forming machine was used to model the 40mm PVC boards to the required shape.
4. The shapes were cut from the PVC boards.

5. A mill was used to

to drill four 45mm-long x 6mm-wide holes for the straps.

6. The 40mm-wide nylon strap was cut to the required length and Velcro was attached to it.

7. A sheet of form board was pasted on the inside of each piece.

8. The nylon strap and the Velcro were attached to each part.

Ankles:

Fig. 18: The Ankle Section

1. Wood was cut to make a model base.

2. The two lower components were cut.

3. A paper model was pasted to the PVC board to cut two back components.

4. Four 45mm-long x 6mm-wide holes were drilled in the back of each component.

5. The back components were heated to make them soft, and were then bent using the wooden model.

6. The lower components were fixed to the rear ones.

7. The sheets were pasted to each part.

8. The 40mm-wide nylon strap was cut to the required length and had Velcro attached to it.

9. The nylon strap and Velcro were attached to each part.

5.8 The Scenario Development

The researcher then used the rationale to develop a SOP, which consisted of a description of the environment and tool setting, and a role playing process relating to time management.

Part one: Environment and tool setting

The tools used in the experiment were:

a. *Empathy tool:* This was made to simulate the physical challenges facing the subject.

b. *Wheelchair:* the subject used an electric wheelchair in his home and at work. For safety reasons, the author could not borrow the subject's wheelchair for the experiment, so the researcher used a manual wheelchair to simulate it.

c. *A folding chair:* the subject used a folding chair while working. The researcher used the same type of folding chair in the experiment to simulate the environment.

d. *Lottery tickets:* the researcher prepared some real lottery tickets for the empathy process. This brought the experience for the participant designers closer to the real situation.

e. *Laptop bag:* this was the same bag with which the lottery company had provided the subject.

f. *Wooden board:* the subject uses a wooden board as a table. The researcher prepared a wooden board to simulate it.

g. *Recording tools:* a digital camera, digital sound recorder and video recorder were

used to record the experiment process.

In addition, the role play process needed somebody to play the role of the client, asking questions of the designer and buying lottery tickets from them.

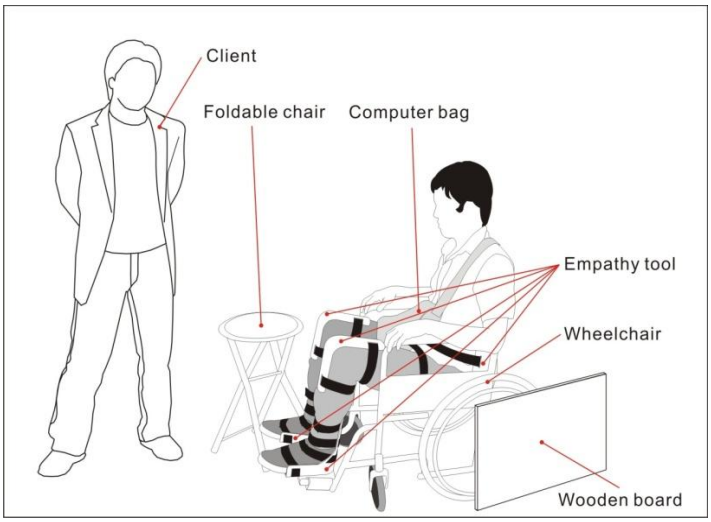


Fig.19: The Tools Used in the Assessment

Part two: The role play procedure

The whole procedure took about 25 minutes. In order to recreate the communication difficulties experienced by the subject, the participant designer was not allowed to speak during the procedure. Ethical issues had to be carefully regarded. If the participant felt any physical or emotional discomfort, the procedure had to be stopped immediately.

Table 11: The Role Play Procedure

Introduction (5 minutes)	The role play procedure and ethical issues are described to the participant.
Environment setting (5 minutes)	Setting the environment; helping the participant to wear the empathy tool and ask him to sit in the wheelchair; giving him

	lottery tickets.
Change position (2 minutes)	Asingk the participant to open the folding chair and to transferfrom the wheelchair to the folding chair.
Workstation installation (2 minutes)	Asking the participant to install the workstation.
Selling process 1 (2 minutes)	The client buys a lottery ticket from the participant, asks the price and chooses the ticket (the participant cannot use verbal communication)
Selling process 2 (2 minutes)	The client asks the participant to match the numbers of the lottery tickets and the participant tells him if it is a match or not. (the participant cannot use verbal communication)
Dismantle the workstation (2 minutes)	Asking the participant to dismantle the work station
Change position (2 minutes)	Ask the participant to transfer from the folding chair to the wheelchair, and to close the folding chair

5.9 Evaluation

After the empathy tool was developed, the researcher evaluated it. He asked two participants to wear it and sit in a chair. He then measured the difference in the time it took them to perform these actions before and after they wore the tool.

The researcher asked the participants to sit in a standard wheelchair, and helped them to put on the empathy tool. It was very easy to put on, and the structure was

very easy to understand after they were given a short description. It fitted the bodies of both participants, and neither of them felt any discomfort while wearing it.

The researcher then asked the participants to perform the following activities in order to observe the effects of the tool's three components on movement:

1. Straighten and flex their lower limbs.
2. Perform flexion, eversion and inversion of the ankles.
3. Stand up.

When the participants tried to straighten and flex their lower limbs, the researcher took pictures and measured the angle of movement. The results showed that the knee section bent the lower limbs effectively. It had less than 15 degrees of movement; and the empathy tool did not break during the process.

Participants found it almost impossible to flex, evert and invert their ankles while wearing the tool. Although the female participant felt that her foot was a little loose in the ankle section, the rigid material did not allow her to flex her foot.

The participants felt that standing up was the most difficult of the three activities. The tool effectively restricted their activity under the waist. They could not stand up without using the armrests to take their body weight.

As a result, the tool very successfully limited the activities of the participant users. No part of it broke during the evaluation process, and the participants did not feel

uncomfortable during the process. Although the participants tried hard to use their muscular strength to stand up, the joints of the hip, knee and ankle were bent at 90 degrees; this disordered their lower bodies, which was the empathy tool's purpose.

The researcher also took the tool and the evaluation records to show two AT research experts in Taiwan in the hope they could give him some suggestions. One of them suggested he shorten the waist section so that its upper edge was below the tenth rib. This means the participants would not feel uncomfortable if they rotated their waists too much.

The other expert advised him not to bend the waist section. Because the PVC material is very slippery, it could simulate an unstable sitting position, which is just like the subject in his wheelchair. In the following role play process, however, the researcher asked the participants to transfer from the wheelchair to the folding chair. As the empathy tool should bend the waist within the movement, he did not use this advice for his design.

The second expert argued that the feeling of a paralysed lower limb is different to that given by the rigid empathy tool, which may cause the designers' sensations to differ from those of the subject. However, it is almost impossible to paralyse a healthy person without using medical means. The empathy tool restricted the lower limbs of the users to a certain degree and successfully made the participant users lose the muscle strength in their lower limbs.

The subject also contributed his own suggestions to the empathy tool. He appreciated the design, and felt that it could simulate the condition of his lower limbs. In addition, he was worried about the short length of time involved in the role play phase. He stated that most of his discomfort came from spending a long time in the same sitting posture, especially when working in the humid Taiwanese climate. He suggested that if the users could sit in the wheelchair for longer than one hour, they might gain more experience of the difficulties he experiences.

Overall, most of the evaluator feedback was positive. They believed the empathy tool could accurately simulate the situation of the subject without causing users harm or significant discomfort. Some of them made their own suggestions, all of which will be taken into consideration before being used for the designer assessment. The researcher will try his best to improve the empathy tool accordingly.

5.10 Summary

An appropriate empathy tool is essential in the empathic design process. It provides designers with the correct experience of the subject's physical limitations and emotional feelings, and helps them make the right decisions in the AT design process.

In this research, the researcher chose a disabled lottery ticket seller as the subject, studied his physical condition and working environment and analysing the tasks

involved in his work in order to develop an empathy tool and a simulated SOP. The empathy tool was then evaluated by designers, AT experts and the subject himself.

The results of the evaluation indicated that the empathy tool successfully simulated the subject's physical condition. Most evaluators gave it positive feedback and believed the tool could help designers understand the subject's difficulties. Some made suggestions which researcher will use to improve the tool's efficiency.

Chapter 6

Empathy Tool Assessment

6.1 Introduction

Much research has indicated that the empathic design concept could help designers realise users' real needs the concept has been widely practiced in many design fields to that end. Successful examples have used specially designed suits to allow designers to experience the difficulties of elderly people when designing vehicles and public facilities. However, it has rarely been implemented in designing AT for individual disabled people, especially not as regards job accommodation.

The findings in Chapter 3 made the researcher realise that every disabled person has his or her own unique physical conditions and living environment, and that these are often very different to those of people without disabilities. Some of these difficulties are not obvious, and even a professional person could not recognise them using traditional methods. Therefore, disabled people are often dissatisfied with the ATs they currently use.

To solve this problem the researcher developed an empathic design process using a specially designed empathy tool to simulate the physical conditions and working environment of an individual subject, and recruited designers to use the empathy tool in order to experience the difficulties faced by the subject.

In Chapter 4 the researcher describes selecting the subject and recording his

physical conditions, work environment and the tasks involved in his job. He then used a human body statistics database and his design skills to construct an empathy tool for designers, which he then tested on them. The tool successfully simulated the physical difficulties faced by the subject.

In this chapter the researcher used the empathy tool to conduct an experiment with the product designers, letting them experience the subject's difficulties. He then designed a role play process to allow the designers to simulate the subject's work process and asked to design a workstation for the subject at every stage. Finally, he invited three experts in AT for job accommodation to judge the designers' work, before analysing the results of their judgements.

These results showed that the empathic design concept had indeed improved designers' understanding of the subject and consequently their designs, which they were able to improve further depending on the level of information they received from the researcher. They also discovered that they could not have anticipated some of the difficulties they encountered, so if they hadn't participated in the research they would never have understood a disabled person's real needs.

However, the empathy tool set could only simulate certain physical aspects. Some relevant design information such as that pertaining to psychology or financial situation cannot be determined using empathic design. Traditional design research methods such as interviews and observations still play an important role in the design process.

The aim of this research was to investigate the improvements to the empathy tool used by the participating designers, and evaluate and to analyse the results in order to find out what kind of design elements could be bettered through the empathic design process.

6.2 The Assessment SOP

To standardise the assessment the researcher designed a SOP. The procedure was divided into four parts: participant selection, assessment tools, assessment procedure and evaluation procedure.

6.2.1 Participant Designers Selection Criteria

To carry out the research, the author selected several product designers to participate in the assessment. The criteria of the selection were:

- Participants must be living in Taiwan, so that they are familiar with the subject's environment.
- Participants must have at least two years' experience of product design, so they have basic knowledge of the subject and can produce graphic sketches.
- They must be aged between 20 and 35, making them part of the new generation of designers. It is thus easier for them to accept the new design method.
- They must be in a healthy physical condition.

6.2.2 Assessment Tools

The tools used in the assessment were:

Empathy tool: according to the subject's physical limitations, the researcher made an empathy tool set to allow participant designers to simulate the subject's situation. The design's details are described in Chapter 4.

A wheelchair: the subject used an electric wheelchair at home and at work. For safety reasons the author could not borrow this wheelchair for the experiment, but a manual standard-sized wheelchair could still mimic the size of the subject's chair.

A folding chair: the subject used this when he was working. To simulate the working environment the assessment required the same type of chair for the process.

Lottery tickets: the procedure required the participant designers to play the role of a lottery seller, so some lottery tickets were needed for the process.

Laptop bag: the lottery company provided the subject with a bag. This is standard equipment for all lottery sellers, so it was essential in the assessment procedure.

Recording tools: a digital camera, digital sound recorder and video recorder were used to record the experimental process.

6.2.3 Assessment Space

Because the designers involved in the investigation were living in a different area of

Taiwan from the subject, the assessment took place in Taipei City and Kaohsiung City, the biggest cities in the north and south of Taiwan respectively.

The assessment needed two types of space: an indoor space that allowed the researcher to display a video as well as computer slides to the participants and allowed them to write and sketch their designs, and an outdoor sidewalk under a streetlight. The space needed to be quiet and undisturbed, and was used to simulate the working environment.

The time the researcher chose to execute the experiment was at night between 7.00pm and 9.00pm, which was within the subject's working hours.

6.2.4 Assessment Procedure

The 115 minute long assessment was separated into several stages. The researcher provided the participant designers with different levels of information and asked them to suggest the best design for the subject. The assessment procedure is described in Table 12.

Table 12: Assessment Procedure

Preparation 10 minutes	1. Introduction to the research 2. Introduction t the assessment process 3. Introduction to ethical issues 4. Collection of basic participant information 5. Interview regarding current participant design method
Stage 1 10 minutes	Design brief 1. Brief by texts and slides 2. Q&A time
Stage 1-2 20 minutes	Ask participant to execute design 1
Stage 2 10 minutes	Design brief 1. Brief by film 2. Q&A time
Stage 2-2	Ask participant to execute design 2

20 minutes	
Stage 3 20 minutes	Empathy tool experience 1. Install the empathy and environment simulation tools 2. Ask participant to wear the empathy tool 3. Role play procedure 4. Q&A time
Stage 3-2 20 minutes	Ask participant to execute design 3
Stage 4 5 minutes	Interview regarding the empathy tool experience

Before the assessment started, the researcher introduced the assessment to the participating designers.

The researcher needed such basic information regarding the participating designers as work experience, design education background and their current design work, all of which may have affected their decision making.

In Stage 1 he presented the designers with a brief and introduced the subject's age, gender and symptoms. The researcher also showed them a picture of the subject's working environment and the tools he used, together with a diagram of the task analysis.

After the brief the participants were able to ask questions.

For the next stage (1-2), the researcher asked the designers to sketch the best solution and to describe the detail of their design in words.

In Stage 2 the researcher provided two videos of the subject and his work. The first video included the subject selling lottery tickets, as well as chatting to his clients. The second recorded the client scraping the lottery ticket and asking clients to

exchange their prizes. Together with a description by the researcher, this allowed the participants to understand the details of the selling process.

After this video presentation and description the participants were again able to ask questions.

In Stage 2-2 the researcher again asked the participants to sketch and to describe their designs.

Stage 3 was very different to the previous ones. At night the author led the participants to an outdoor space lit by a street light, asked them to wear the empathy tool that he had designed and made as described in Chapter 4, and then – as described in the scenario in that chapter – to transfer from the wheelchair to the folding chair wearing the empathy tool, and to sell a lottery ticket to the researcher without speaking.

After the participants took off the empathy tool, they were able to ask the researcher questions about the subject.

Stage 3-2 was the same as Stage 2-2. The designers described their best solutions using both sketches and words.

In Stage 4 the researcher elicited the designers' views regarding the empathy tool practice and their opinions of how it could affect the design process.

6.2.5 Evaluation Procedure

After the assessment the author collected the designer's sketches and descriptions and invited three job accommodation AT experts to judge the quality of the designs.

To avoid personal bias and the risk of having the style or quality of the sketches affect judgement, the researcher repainted all of them and allotted each a random number before making each sketch into a card, each of which listed ten important job accommodation AT design elements which the researcher had compiled from previous research and expert interviews. He used a five level ranking system to help the experts make their judgements.

The design elements are:

- *The user's physical ability.* This is the most important element in the AT design, without an understanding of which the AT design could miscarry. It is also the key goal of this assessment.

- *Work requirement.* The designer was asked to design an AT that could be used in the subject's work environment. Suitable designs for work requirements are therefore very different. They include safety issues, advertisement and transportation.

- *Ergonomic issues.* Although a sustainable job could help the subject achieve psychological self-actualization, long-term work could also cause his physical condition to deteriorate. A design that considered such ergonomic issues could

help the subject reduce this circumstantial problem.

- *Consideration of both user and employee (client).* In a general job accommodation case, one of the most important elements is a consideration of the employee's opinion. However, in this case, the subject is self-employed. The most important considerations as regards the client are ticket purchase, communication and the process of prize changing.

- *User preference.* Users have their own preferences: some prefer technologically sophisticated products whereas others are partial to more basic ones. This is also a vital element in AT design. An AT that meets the user's preferences could encourage them to use it with pleasure, and therefore longer and more often.

- *Environmental characteristics.* Users have a variety of living environments, and the ambient light, ground surface, size of space and noise from the surroundings could all affect the AT's performance.

- *Simplicity.* Simple, easy to use products are always welcomed by customers.

- *Low cost.* Cost is always important in every product design. Statistically, the average incomes of disabled people are far lower than those of people without disabilities, so considerations of cost are more important in AT design than they are for normal products.

- *Durability.* A piece of AT may be used long-term, so durability is essential. This is especially so if the subject is working outdoors in the wind and rain and customers can damage it.

- *Integrity.* Design improvements could make the product complicated, as too many separate tools are often easy to lose and difficult to manage.

The researcher assumed that the empathy tool was more likely to improve the physical than the psychological aspects of the design, as knowledge regarding the latter is more difficult to impart to designers using physical devices. For instance, the level of cost is difficult to define, as it is relative. Such elements as durability and simplicity also need to be improved using the designer's own knowledge; they cannot be taught in a short time.

The researcher therefore divided the ten elements into two groups. Those such as a user's physical abilities, work requirements, ergonomics, environment and the consideration of the client are Part A: they are more easily learned by short-term experience. Elements such as user preferences, simplicity, low cost, durability and integrity comprise Part B, and require a long-term assimilation, as they are difficult to learn. The two parts are as follows:

Part A

1. The user's physical abilities
2. Work requirement

3. Ergonomics

4. Environment characteristics

5. Considerations of both user and employer (client)

Part B

1. The user's preferences

2. Simplicity

3. Low cost

4. Durability

5. Integrity

6.3 Assessment

The assessment took place between July and September 2009 in the cities of Taipei and Kaohsiung. The author prepared a set of assessment tools for each of the two locations in order to execute the assessments.

6.3.1 Participant Designers' Information

In total, the author found 12 designers to participate in the assessments in Taiwan. One became pregnant and another could not finish the assessment, which left ten who completed the experiment.

Six were from Taipei and the others from Kaohsiung. Four were male, all were between the ages of 25 and 35 and all had more than two years' design work

experience.

As Taiwan is famous for manufacturing digital consumer products, it is unsurprising that seven of the designers came from the consumer product design field. The others were shoe, interior and clothing designers. All had graduate or postgraduate degrees with design majors, most from both Taiwan and overseas. The details of their personal information are listed in Table 13.

Table 13: Details of Information Regarding Participating Designers

Participant number	1	2	3	4	5	6	7	8	9	10
Gender	F	M	M	F	M	M	F	F	F	F
Age	30	35	27	29	35	29	28	26	32	27
Work experience (years)	6.2	6.5	2.2	3.5	6	3	2.5	2.8	4	4.5
Location	K	K	T	K	T	T	K	K	T	T
Current work	I	P	P	S	P	P	S	B	P	P
M: Male F: Female T: Taipei K: Kaohsiung P: Product design I: Interior design S: Shoe design B: Body wear design										

6.3.2 Assessment Execution

The assessments in both Taipei and Kaohsiung took place in private premises between 7:00pm and 9:00pm, which was same as the subject's normal working hours. The researcher used the living rooms of the houses to present the computer slides and films (Stages 1 and 2), and used the sidewalk outside the houses to put the empathy tool into practice (Stage 3). Finally, everyone returned to the living room for the final design and to submit their opinions on the experience of using the empathy tool.

As the researcher only had one empathy tool set, and the assessment process was complicated, the researcher could only allow one participant designer to undergo

the assessment at a time. Therefore, it took three weeks to finish the assessments.

6.3.3 Evaluation Execution

After the assessments, the researcher recorded the interviews and sketches using text and pictures. He then redrew the sketches one by one, putting each of them onto an evaluation card, and gave each card a random number. A sample of the evaluation card is show in Table 14 Samples of designs are attached in Appendix B.

The evaluation card included a random number as well as the evaluator's name, the design itself and ten questions that used a five-rank system to ask the evaluator about the design's degree of success.

Table 14: A Sample Evaluation Card

No.		Evaluator	
Design Work			

Please complete the following questions	Strongly agree	Agree	Neither	Disagree	Strongly disagree
Q1. Do you think this design is considered user's physical ability?					
Q2. Do you think this design is considered work requirements?					
Q3. Do you think this design is considered ergonomics?					
Q4. Do you think this design is considered environment characteristics?					
Q5. Do you think this design is considered both user and employer (clients)?					
Q6. Do you think this design is considered user's preference?					
Q7. Do you think this design is considered simplicity?					
Q8. Do you think this design is considered cost?					
Q9. Do you think this design is considered durability?					
Q10. Do you think this design is considered integrity?					

The researcher invited three job accommodation experts to be evaluators in Taiwan

and gave them information about the subject and how to score the design.

The three experts were fully experienced in job accommodation AT. As they were resident in Taiwan, they also had a thorough understanding of job accommodation and the possibilities for AT design in Taiwan.

Both before and after the evaluation the researcher had a group interview with the experts. He wanted to know what opinion they had of the empathy tool, and to understand which design elements of the AT design were most important from their point of view before they started the evaluation.

After the experts scored each design, the researcher reorganised the evaluation cards for each designer, and discussed these with the experts. He wanted to know their views on the improvements, ask their suggestions for the assessment and seek their advice about how to employ the empathic method to the AT job accommodation design process in Taiwan.

He also recorded interviews with the participant designers in the final stage of the assessment, which concerned their opinions of the assessment. A qualitative analysis method was used to analyse all the data.

6.4 Assessment Results

After the assessment and evaluation had taken place the researcher collected all the results and used Microsoft Office's Excel programme to record the results. The raw data are shown in Table 15.

Table 15: The 30 Design Scores After the Evaluation Process

Design	Number	Assessor	Ability	Task	Ergonomics	Environment	Client	Preference	Simplicity	Cost	Durability	Integrity	Average
1-1	2938	A	3.00	2.00	3.00	3.00	3.00	2.00	3.00	2.00	2.00	2.00	2.50
1-1	2938	B	3.00	2.00	3.00	4.00	2.00	3.00	4.00	3.00	2.00	2.00	2.80
1-1	2938	C	3.00	3.00	3.00	3.00	3.00	4.00	4.00	4.00	3.00	2.00	3.20
1-1	2938	Average	3.00	2.33	3.00	3.33	2.67	3.00	3.67	3.00	2.33	2.00	2.83
1-2	2915	A	4.00	3.00	4.00	3.00	4.00	4.00	4.00	3.00	4.00	3.00	3.60
1-2	2915	B	2.00	4.00	2.00	4.00	4.00	4.00	5.00	4.00	4.00	2.00	3.50
1-2	2915	C	4.00	4.00	3.00	4.00	4.00	3.00	3.00	3.00	4.00	2.00	3.40
1-2	2915	Average	3.33	3.67	3.00	3.67	4.00	3.67	4.00	3.33	4.00	2.33	3.50
1-3	2911	A	4.00	4.00	3.00	5.00	4.00	3.00	4.00	3.00	3.00	3.00	3.60
1-3	2911	B	5.00	5.00	4.00	5.00	4.00	4.00	5.00	5.00	4.00	4.00	4.50
1-3	2911	C	3.00	5.00	4.00	4.00	5.00	4.00	4.00	4.00	5.00	4.00	4.20
1-3	2911	Average	4.00	4.67	3.67	4.67	4.33	3.67	4.33	4.00	4.00	3.67	4.10
2-1	2914	A	3.00	3.00	2.00	3.00	2.00	3.00	2.00	3.00	3.00	2.00	2.60
2-1	2914	B	4.00	4.00	2.00	4.00	3.00	3.00	4.00	4.00	4.00	3.00	3.50
2-1	2914	C	4.00	4.00	4.00	5.00	3.00	4.00	4.00	4.00	4.00	4.00	4.00
2-1	2914	Average	3.67	3.67	2.67	4.00	2.67	3.33	3.33	3.67	3.67	3.00	3.37
2-2	2913	A	2.00	3.00	2.00	3.00	3.00	2.00	2.00	3.00	3.00	4.00	2.70
2-2	2913	B	5.00	4.00	2.00	4.00	3.00	5.00	5.00	5.00	5.00	4.00	4.20
2-2	2913	C	4.00	5.00	4.00	5.00	4.00	5.00	4.00	4.00	4.00	4.00	4.30
2-2	2913	Average	3.67	4.00	2.67	4.00	3.33	4.00	3.67	4.00	4.00	4.00	3.73
2-3	2924	A	4.00	4.00	3.00	4.00	3.00	4.00	4.00	5.00	3.00	4.00	3.80
2-3	2924	B	5.00	4.00	3.00	4.00	4.00	5.00	4.00	4.00	4.00	4.00	4.10
2-3	2924	C	4.00	5.00	4.00	5.00	4.00	4.00	5.00	5.00	5.00	5.00	4.60
2-3	2924	Average	4.33	4.33	3.33	4.33	3.67	4.33	4.33	4.67	4.00	4.33	4.17
3-1	2931	A	3.00	2.00	2.00	3.00	2.00	3.00	4.00	4.00	4.00	2.00	2.90
3-1	2931	B	3.00	4.00	2.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
3-1	2931	C	3.00	4.00	3.00	3.00	3.00	5.00	4.00	5.00	5.00	3.00	3.80
3-1	2931	Average	3.00	3.33	2.33	3.00	2.67	3.67	3.67	4.00	4.00	2.67	3.23
3-2	2923	A	3.00	3.00	3.00	3.00	3.00	3.00	4.00	3.00	3.00	2.00	3.00
3-2	2923	B	4.00	4.00	2.00	4.00	5.00	4.00	4.00	4.00	5.00	5.00	4.10
3-2	2923	C	3.00	5.00	3.00	3.00	4.00	4.00	4.00	5.00	4.00	3.00	3.80
3-2	2923	Average	3.33	4.00	2.67	3.33	4.00	3.67	4.00	4.00	4.00	3.33	3.63
3-3	2919	A	4.00	4.00	2.00	4.00	2.00	3.00	4.00	4.00	3.00	2.00	3.20
3-3	2919	B	4.00	4.00	3.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	3.90
3-3	2919	C	4.00	5.00	4.00	4.00	5.00	3.00	3.00	4.00	4.00	3.00	3.90
3-3	2919	Average	4.00	4.33	3.00	4.00	3.67	3.33	3.67	4.00	3.67	3.00	3.67
4-1	2912	A	2.00	2.00	1.00	2.00	2.00	3.00	2.00	2.00	2.00	2.00	2.00
4-1	2912	B	2.00	4.00	2.00	2.00	4.00	3.00	4.00	4.00	4.00	4.00	3.30
4-1	2912	C	2.00	4.00	2.00	3.00	4.00	4.00	3.00	4.00	4.00	5.00	3.50
4-1	2912	Average	2.00	3.33	1.67	2.33	3.33	3.33	3.00	3.33	3.33	3.67	2.93
4-2	2930	A	3.00	4.00	2.00	3.00	3.00	4.00	4.00	4.00	3.00	3.00	3.30
4-2	2930	B	3.00	3.00	2.00	3.00	4.00	3.00	3.00	4.00	4.00	4.00	3.30
4-2	2930	C	3.00	4.00	3.00	3.00	3.00	4.00	4.00	5.00	4.00	4.00	3.70
4-2	2930	Average	3.00	3.67	2.33	3.00	3.33	3.67	3.67	4.33	3.67	3.67	3.43
4-3	2939	A	3.00	4.00	2.00	3.00	4.00	3.00	3.00	4.00	4.00	2.00	3.20
4-3	2939	B	4.00	5.00	3.00	4.00	3.00	3.00	4.00	4.00	4.00	4.00	3.80
4-3	2939	C	3.00	4.00	3.00	3.00	3.00	3.00	3.00	4.00	3.00	2.00	3.10
4-3	2939	Average	3.33	4.33	2.67	3.33	3.33	3.00	3.33	4.00	3.67	2.67	3.37
5-1	2918	A	2.00	3.00	2.00	4.00	3.00	3.00	3.00	4.00	4.00	3.00	3.10
5-1	2918	B	4.00	2.00	2.00	2.00	3.00	3.00	4.00	4.00	4.00	4.00	3.20
5-1	2918	C	4.00	3.00	2.00	3.00	3.00	3.00	3.00	4.00	4.00	4.00	3.30
5-1	2918	Average	3.33	2.67	2.00	3.00	3.00	3.00	3.33	4.00	4.00	3.67	3.20
5-2	2917	A	4.00	2.00	2.00	4.00	4.00	2.00	3.00	2.00	3.00	3.00	2.90
5-2	2917	B	2.00	3.00	3.00	3.00	4.00	2.00	3.00	2.00	3.00	4.00	2.90
5-2	2917	C	4.00	4.00	3.00	3.00	4.00	4.00	5.00	2.00	3.00	4.00	3.60

Design	Number	Assessor	Ability	Task	Ergonomics	Environment	Client	Preference	Simplicity	Cost	Durability	Integrity	Average
6-1	2928	A	3.00	3.00	1.00	3.00	3.00	3.00	3.00	2.00	3.00	2.00	2.60
6-1	2928	B	3.00	3.00	2.00	3.00	3.00	4.00	3.00	3.00	3.00	3.00	3.00
6-1	2928	C	4.00	4.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.20
6-1	2928	Average	3.33	3.33	2.00	3.00	3.00	3.33	3.00	2.67	3.00	2.67	2.93
6-2	2926	A	3.00	3.00	4.00	4.00	3.00	3.00	2.00	2.00	2.00	3.00	2.90
6-2	2926	B	4.00	4.00	3.00	3.00	4.00	4.00	4.00	3.00	3.00	4.00	3.60
6-2	2926	C	4.00	3.00	4.00	3.00	4.00	3.00	3.00	2.00	4.00	3.00	3.30
6-2	2926	Average	3.67	3.33	3.67	3.33	3.67	3.33	3.00	2.33	3.00	3.33	3.27
6-3	2920	A	4.00	3.00	2.00	4.00	4.00	4.00	3.00	1.00	3.00	4.00	3.20
6-3	2920	B	5.00	5.00	3.00	4.00	5.00	2.00	4.00	3.00	4.00	4.00	3.90
6-3	2920	C	5.00	5.00	4.00	4.00	3.00	2.00	2.00	2.00	4.00	3.00	3.40
6-3	2920	Average	4.67	4.33	3.00	4.00	4.00	2.67	3.00	2.00	3.67	3.67	3.50
7-1	2925	A	2.00	2.00	2.00	2.00	3.00	2.00	2.00	3.00	3.00	2.00	2.30
7-1	2925	B	2.00	4.00	2.00	3.00	3.00	4.00	5.00	5.00	5.00	5.00	3.80
7-1	2925	C	3.00	4.00	3.00	3.00	4.00	2.00	3.00	3.00	3.00	4.00	3.20
7-1	2925	Average	2.33	3.33	2.33	2.67	3.33	2.67	3.33	3.67	3.67	3.67	3.10
7-2	2934	A	3.00	3.00	2.00	4.00	4.00	3.00	3.00	4.00	3.00	3.00	3.20
7-2	2934	B	3.00	4.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	4.00	3.20
7-2	2934	C	4.00	5.00	3.00	4.00	4.00	3.00	3.00	3.00	4.00	4.00	3.70
7-2	2934	Average	3.33	4.00	2.67	3.67	3.67	3.00	3.00	3.33	3.33	3.67	3.37
7-3	2927	A	2.00	3.00	3.00	4.00	4.00	3.00	2.00	3.00	2.00	2.00	2.80
7-3	2927	B	5.00	5.00	3.00	5.00	4.00	2.00	3.00	3.00	3.00	5.00	3.80
7-3	2927	C	5.00	5.00	3.00	4.00	5.00	3.00	3.00	3.00	3.00	4.00	3.80
7-3	2927	Average	4.00	4.33	3.00	4.33	4.33	2.67	2.67	3.00	2.67	3.67	3.47
8-1	2916	A	2.00	3.00	2.00	3.00	4.00	2.00	3.00	3.00	3.00	3.00	2.80
8-1	2916	B	4.00	3.00	2.00	2.00	4.00	3.00	4.00	2.00	2.00	3.00	2.90
8-1	2916	C	4.00	5.00	3.00	3.00	3.00	2.00	2.00	2.00	3.00	4.00	3.10
8-1	2916	Average	3.33	3.67	2.33	2.67	3.67	2.33	3.00	2.33	2.67	3.33	2.93
8-2	2922	A	5.00	4.00	4.00	4.00	5.00	4.00	3.00	2.00	3.00	4.00	3.80
8-2	2922	B	4.00	3.00	2.00	3.00	4.00	2.00	2.00	2.00	3.00	2.00	2.70
8-2	2922	C	4.00	5.00	2.00	3.00	4.00	2.00	2.00	3.00	3.00	3.00	3.10
8-2	2922	Average	3.67	3.67	3.67	3.00	3.67	3.00	2.67	2.33	3.00	3.03	3.17
8-3	2936	A	4.00	4.00	4.00	4.00	4.00	4.00	4.00	2.00	3.00	4.00	3.70
8-3	2936	B	3.00	5.00	4.00	5.00	5.00	3.00	3.00	3.00	3.00	2.00	3.60
8-3	2936	C	3.00	4.00	4.00	4.00	4.00	2.00	1.00	3.00	3.00	2.00	3.00
8-3	2936	Average	3.33	4.33	4.00	4.33	4.33	3.00	2.67	2.67	3.00	2.67	3.43
9-1	2929	A	2.00	2.00	1.00	1.00	2.00	2.00	1.00	3.00	3.00	2.00	1.90
9-1	2929	B	3.00	4.00	3.00	2.00	2.00	3.00	3.00	3.00	4.00	4.00	3.10
9-1	2929	C	2.00	2.00	3.00	2.00	3.00	2.00	2.00	3.00	3.00	2.00	2.40
9-1	2929	Average	2.33	2.67	2.33	1.67	2.33	2.33	2.00	3.00	3.33	2.67	2.47
9-2	2932	A	3.00	4.00	4.00	3.00	3.00	3.00	2.00	4.00	3.00	4.00	3.30
9-2	2932	B	2.00	4.00	2.00	2.00	5.00	4.00	2.00	3.00	3.00	1.00	2.80
9-2	2932	C	2.00	4.00	3.00	3.00	4.00	4.00	3.00	3.00	3.00	2.00	3.10
9-2	2932	Average	2.33	4.00	3.00	2.67	4.00	3.67	2.33	3.33	3.00	2.33	3.07
9-3	2935	A	4.00	4.00	4.00	4.00	4.00	4.00	3.00	4.00	3.00	4.00	3.80
9-3	2935	B	5.00	5.00	5.00	3.00	5.00	5.00	4.00	4.00	3.00	4.00	4.30
9-3	2935	C	5.00	5.00	4.00	4.00	4.00	4.00	4.00	5.00	4.00	3.00	4.20
9-3	2935	Average	4.67	4.67	4.33	3.67	4.33	4.33	3.67	4.33	3.33	3.67	4.10
10-1	2921	A	4.00	3.00	4.00	4.00	3.00	4.00	4.00	5.00	4.00	3.00	3.80
10-1	2921	B	3.00	3.00	4.00	2.00	2.00	4.00	4.00	3.00	4.00	4.00	3.30
10-1	2921	C	5.00	2.00	3.00	3.00	3.00	5.00	5.00	4.00	4.00	4.00	3.80
10-1	2921	Average	4.00	2.67	3.67	3.00	2.67	4.33	4.33	4.00	4.00	3.67	3.63
10-2	2937	A	3.00	3.00	4.00	4.00	2.00	3.00	4.00	4.00	4.00	3.00	3.40
10-2	2937	B	4.00	4.00	5.00	3.00	4.00	4.00	5.00	5.00	5.00	5.00	4.40
10-2	2937	C	4.00	4.00	4.00	3.00	3.00	4.00	4.00	4.00	5.00	4.00	3.90

6.5 Analysis and Discussion

The large amounts of data comprising the assessment results were difficult to analyse, but the author has carried out some evaluation in order to make them clearer. Firstly, to avoid individual assessor bias he equalised the three scores for each design into one, as listed in Table 16.

Table 16: The 30 Designs Scores after Equalisation

	Ability	Task	Ergonomics	Environment	Client	Preference	Simplicity	Cost	Durability	Integrity
1-1	3	2.33	3	3.33	2.67	3	3.67	3	2.33	2
1-2	3.33	3.67	3	3.67	4	3.67	4	3.33	4	2.33
1-3	4	4.67	3.67	4.67	4.33	3.67	4.33	4	4	3.67
2-1	3.67	3.67	2.67	4	2.67	3.33	3.33	3.67	3.67	3
2-2	3.67	4	2.67	4	3.33	4	3.67	4	4	4
2-3	4.33	4.33	3.33	4.33	3.67	4.33	4.33	4.67	4	4.33
3-1	3	3.33	2.33	3	2.67	3.67	3.67	4	4	2.67
3-2	3.33	4	2.67	3.33	4	3.67	4	4	4	3.33
3-3	4	4.33	3	4	3.67	3.33	3.67	4	3.67	3
4-1	2	3.33	1.67	2.33	3.33	3.33	3	3.33	3.33	3.67
4-2	3	3.67	2.33	3	3.33	3.67	3.67	4.33	3.67	3.67
4-3	3.33	4.33	2.67	3.33	3.33	3	3.33	4	3.67	2.67
5-1	3.33	2.67	2	3	3	3	3.33	4	4	3.67
5-2	3.33	3	2.67	3.33	4	2.67	3.67	2	3	3.67
5-3	4.67	4.33	4	3.67	4	3.67	3.67	3	4	3.33
6-1	3.33	3.33	2	3	3	3.33	3	2.67	3	2.67
6-2	3.67	3.33	3.67	3.33	3.67	3.33	3	2.33	3	3.33
6-3	4.67	4.33	3	4	4	2.67	3	2	3.67	3.67
7-1	2.33	3.33	2.33	2.67	3.33	2.67	3.33	3.67	3.67	3.67
7-2	3.33	4	2.67	3.67	3.67	3	3	3.33	3.33	3.67
7-3	4	4.33	3	4.33	4.33	2.67	2.67	2.33	2.67	3.67
8-1	3.33	3.67	2.33	2.67	3.67	2.33	3	2.33	2.67	3.33
8-2	3.67	3.67	3.67	3	3.67	3	2.67	2.33	3	3.03
8-3	3.33	4.33	4	4.33	4.33	3	2.67	2.67	3	2.67
9-1	2.33	2.67	2.33	1.67	2.33	2.33	2	3	3.33	2.67
9-2	2.33	4	3	2.67	4	3.67	2.33	3.33	3	2.33
9-3	4.67	4.67	4.33	3.67	4.33	4.33	3.67	4.33	3.33	3.67
10-1	4	2.67	3.67	3	2.67	4.33	4.33	4	4	3.67
10-2	3.67	3.67	4.33	3.33	3	3.67	4.33	4.33	4.67	4
10-3	4.33	4.67	4.67	3.67	4	3.67	3.67	4	4	4

Improved at every stages
Only improved between stage 2 and 3
Worsened between stage 2 and 3
Remained the same

The research focuses on the improvements between Stages 2 and 3. The

researcher has combined the designer and design elements into blocks, using different colours to identify the different levels of performance. Green indicates that the design element's rank has improved stage by stage. Blue showed that the design element had only improved between Stages 2 and 3, Grey that it had remained unchanged and red that it had worsened.

The researcher then calculated each design element. He found that of the total 100 blocks, 48 blocks were green, 16 blue, 21 red and 15 gray. These results showed that 64 per cent of the blocks had improved since the previous assessment, 21 per cent had worsened and 36 per cent had remained unchanged.

It is obvious that the improvements in understanding the user's physical ability, work requirements, ergonomics, work environment and client considerations (i.e. those involved in Part A) are better than those for the user's preferences, design simplicity, cost, durability and integrity (Part B). This matches the researcher's assumptions.

1. *Total Score Analysis*

The researcher also analysed each designer's total score. The scores of all the elements were added together and equalised to make a bar chart (Fig.21) which shows that 80 per cent of the designs have improved as a result of the three-stage design assessment. Each stage scores higher than its predecessor, meaning that both the video presented in Stage 2 and the empathy tool used in the third stage helped the designers improve their designs.

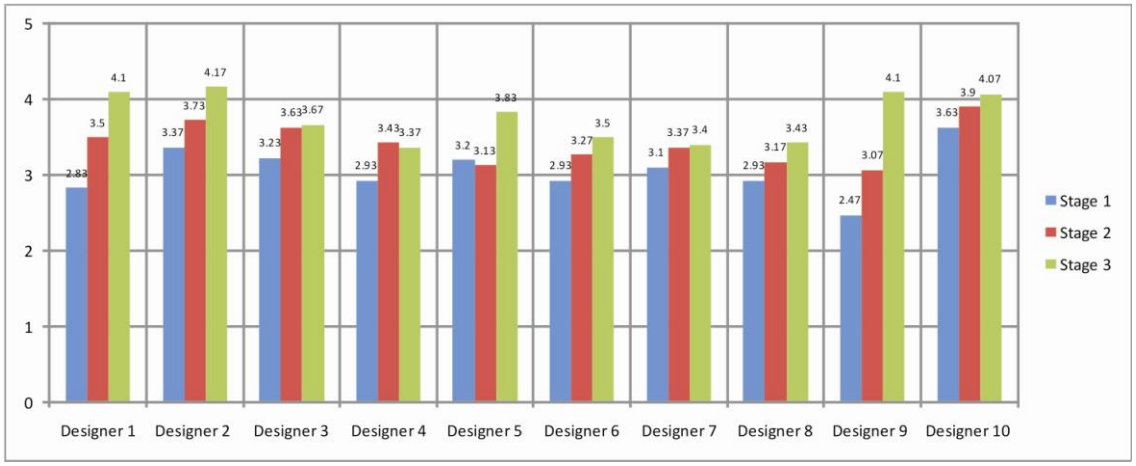


Fig.20. Each Designer's Total Average Scores at Every Stage

All scores are the same except for those of designers 4 and 5 . Designer 4's score for Stage 2 is higher than that for Stage 3, at 0.06. For Designer 5, Stage 1's score is higher than that for Stage 2 (0.07). The reason for these differences could be individual assessor preference. Alternatively, some good design elements may have been removed by the designer after the second assessment, or the total score may have been reduced when some design elements could not be improved using either the video record or the empathy tool. It is difficult to find the true reasons from the limited information in Table 6.5.

In any case these two differences are minor, and the reasons for the reductions are varied. Generally speaking, the total design scores for most designers are improved.

2. *The Total Improvement in Each Element*

To understand which elements had improved after the assessment process, the

researcher calculated each designer's average scores at each stage. The results are show in Table 17

The researcher has also compared the percentage of improvement at each stage, discovering that some design elements have improved markedly from stages 1 to 3. The understanding of the user's physical ability improved by 22 per cent), work requirements by 26.6 per cent, ergonomic requirements by 22.8 per cent, environmental characteristics by 22.6 per cent and the client's requirements by 21.4 per cent. It is obvious that the empathy tool can improve the designers' understanding of these five design elements. The other five elements only improved by less than 10 per cent.

Table 17: The Improved Elements at Every Stage

	Ability	Tasks	Ergonomic	Environment	Client	Preference	Simplicity	Cost	Durability	Integrity	Total
Stage 1	3.03	3.10	2.43	2.87	2.93	3.13	3.27	3.37	3.40	3.10	3.06
Stage 2	3.33	3.70	3.07	3.33	3.67	3.44	3.43	3.33	3.57	3.34	3.42
Stage 3	4.13	4.43	3.57	4.00	4.00	3.43	3.50	3.50	3.60	3.47	3.76

	Ability	Tasks	Ergonomic	Environment	Client	Preference	Simplicity	Cost	Durability	Integrity	Total
S1 and S2	6.0%	12.0%	12.8%	9.2%	14.8%	6.2%	3.2%	-0.8%	3.4%	4.8%	7.2%
S2 and S3	16.0%	14.6%	10.0%	13.4%	6.6%	-0.2%	1.4%	3.4%	0.6%	2.6%	6.8%
S1 and S3	22.0%	26.6%	22.8%	22.6%	21.4%	6.0%	4.6%	2.6%	4.0%	7.4%	14.0%

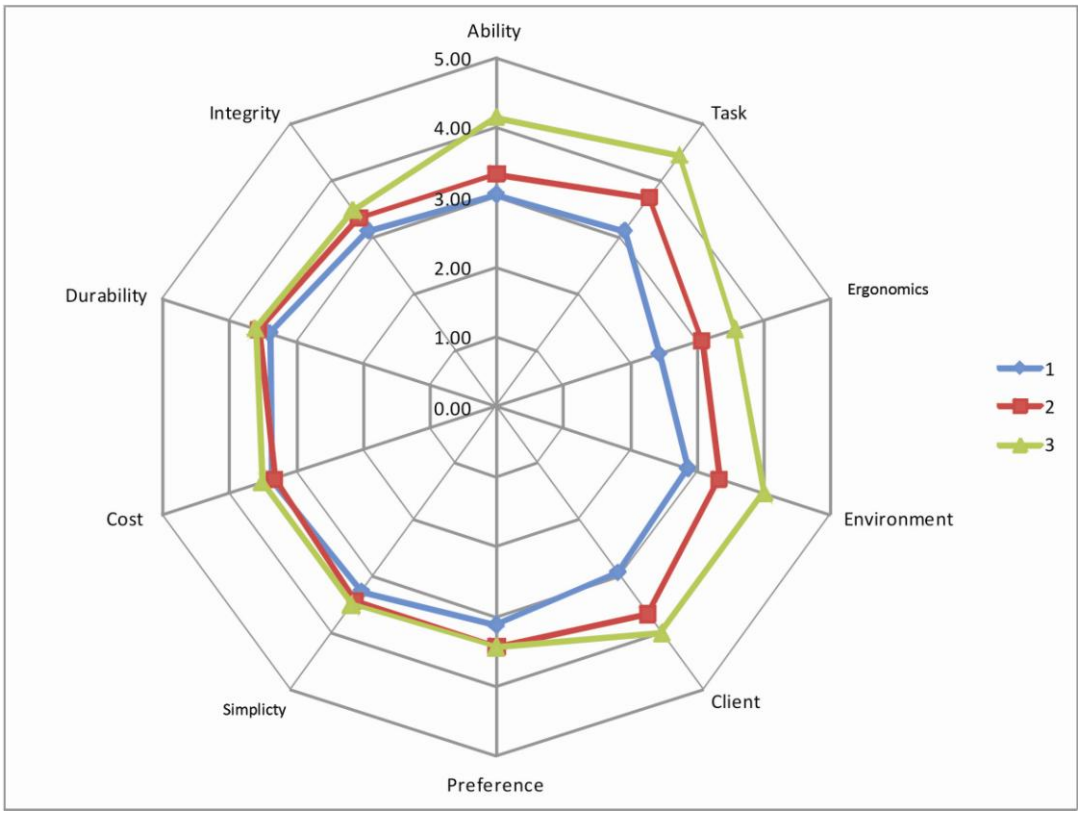


Fig.21: Average Scores of All Designers for All Design Elements

A radar chart (Fig.22) should make the comparison of the improvements clearer. In Chapter 6.3.5 the researcher divided ten selected elements into Parts A and B. It was obvious that those in Part A had improved dramatically, which matched the researcher's assumptions. The figure above also indicates that the designers responded well to the subject's case even after such a short time. This means that they were able to glean information about the subject using the empathy tool, which thereby improved their understanding.

The designers were more likely to need professional education and work experience over a long period of time to improve the elements contained in Part B. Gaining professional knowledge such as an understanding of the price and

durability of a material within such a short period of empathic experience proves far too difficult. The subject's personal preferences can also only be discerned by sophisticated observation, while improved integrity also requires a long period of design experience.

In Fig.23 the researcher has analysed the relationship between design work experience and performance. The participants' work experience was separated into three two-year levels: two to three, four to five and six to seven years. The scores were added together and equalised.

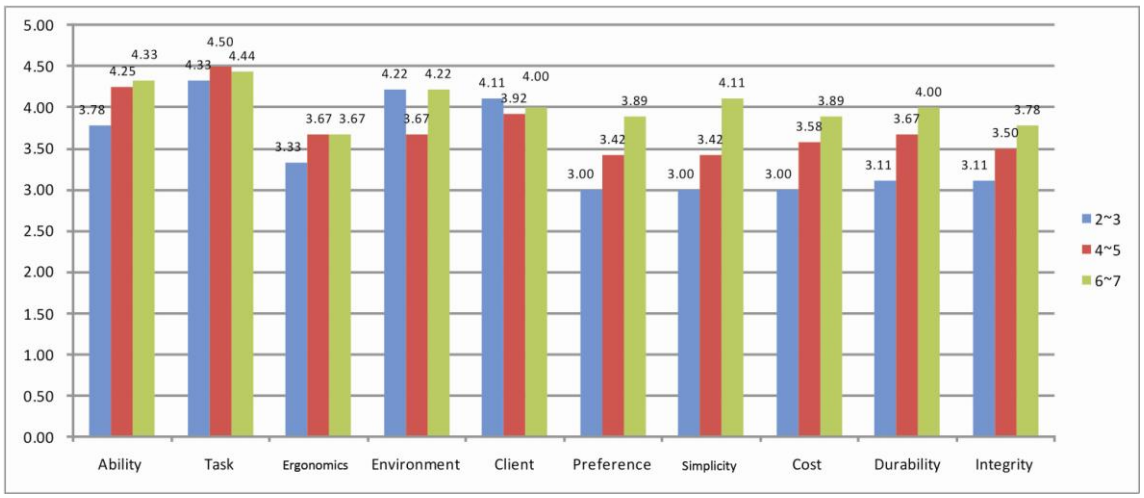


Fig.22: Analysis of Work Experience and Performance of Design Elements

The table reveals marked differences between Parts A and B. In the latter, the participants with greater work experience had higher scores than their less experienced counterparts. The most experienced designers had the highest scores in every element. The results show the striking effect of design work experience on the application of design knowledge. The longer a designer has been working in the design field, the more they absorb design knowledge from their own and their colleagues' work.

However, in Part A there were some very different scores. For the user's ability, work requirements and ergonomics the new designers had the lowest scores, but for work environment and consideration of client needs they scored highest. The scores of other levels of work experience also varied, which implies that work experience may not be related to the design elements of Part A.

Although the empathy tool did help the participant designers improve their knowledge of the elements in Part A, some basic knowledge, such as that regarding the user's physical ability and the ergonomics involved, could allow these improvements to become more apparent. Fig. 23 shows that the new designers improved the design elements to a higher level after they tried the empathy tool. However, the mature designers with more knowledge of human factors could have improved further.

3. *Analysis of the Participant Designer Interviews*

The researcher also interviewed the participant designers regarding their opinions on the empathic design assessment. Eight of them appreciated the effect of this process. They thought that their image of the subject had become more vivid, and they could recognise his abilities and limitations, even though they never met him. In particular, especially in terms of the subject's work space and ergonomic characteristics, they clearly appreciated the scale and physical difficulties of the space involved.

One of the designers worked in the interior design industry. She mentioned that in this context one commonly sees empathic design concepts used regularly, especially in normal family household interior designs. Designers in this field often interviewed house owners and visited houses before starting their designs. However she had no experience of designing for a disabled person.

The designers also believed that if they were called upon to design for a disabled person, the empathic process could help them understand their special needs.

By contrast, two of the participants disagreed with this assessment. One of these was a footwear designer and the other a garment designer. They thought there were some industrial standards that already existed that could fit almost all sizes, and they therefore did not feel the need for empathy tools in their everyday work. They did, however, agree on the effects in understanding the subject in some way. They realised that the empathy process can help them not only in terms of the size issue, but could also allow the designer to discover difficulties, such as communication and the environmental condition of the subject. It could help them design for the individual subject, but they did not think it suitable for the larger population.

An additional avenue to explore as a result of these interviews might be the use of the empathic process in industry. Most participants believed that the main problems involved in using the empathy tool were those regarding time and budget. Some designers described their work schedules as very tight: they did not have enough

time to carry out additional design studies such as empathic processes for specific cases. Some felt that their company's owners would not allow them to spend any of their budgets on such processes. In addition, companies often reckon working times as costs, which would make the empathic process more difficult to implement in an industry setting.

Some designers also mentioned that the attitude of company owners was an important issue. Some owners with positive attitudes might see the process as allowing their designers to gain more design knowledge, which would then mean added value for their companies. On the other hand, some others might think the empathic process to be a waste of time: if their designers wanted such knowledge, they should gain it themselves rather than on company time, especially when the pressures of work were always great.

4. *Analysis of Interviews with the AT Job Accommodation Experts*

The researcher also held a group interview with three experts in AT for job accommodation; these had evaluated the designs as part of the assessment. The group interview took place after the assessment, and the interview questions focused on their opinions of the empathic design in particular and of the designs overall. The researcher used a digital recorder to record and transcribe the interviews.

Their opinion of empathetic design was mostly positive. They thought that such design could help new designers understand subjects and their environments.

However, they still thought that some of the requisite knowledge, such as an understanding of human factors and of material characteristics, is derived from a long period of training in the field. In addition, some AT information and skills often have to be updated regularly. A new design method could improve the understanding of the design subject, but it still needs to be based on traditional methods at a basic design level.

6.6 Summary

The empathy tool was also discussed. They thought it was very difficult to design and make suitable tools for specific design subjects. Time and budget were often the critical problems in producing such tools. Moreover, the method of disability simulation needs to be accurate, otherwise the results of the empathic method would be wrong.

The researcher then asked their opinions about how to introduce the empathic design process into AT design for job accommodation. The experts thought there were still difficulties in execution, time and budget still being the key issues. In addition, the AT supply line still has many problems as the professional value of AT design is still not built correctly. Most AT users are advised by the seller, and public departments can only supervise the selection process if they have financial support for doing so. It is therefore difficult to promote the empathic design process to the industry.

However, the experts believed that empathic design was very useful to job accommodation design. It could not only help new designers quickly realise subjects' real situations, but also give senior designers a thorough understanding of the subject. They also suggested that it could be promoted by training course at universities or in therapists' unions. Although virtual subjects in training courses cannot provide feedback, it would allow students to practice the empathic process and encourage them to use it in their careers.

The experts appreciated the participants' designs, determining most of them to be of a higher than average level. The design works from the final assessment considered the abilities of the subject, the condition of the environment and the difficulties in the work process.

Nevertheless, the participant designers were not from the AT design field and did not have experience in designing for people with disabilities. Their lack of knowledge of AT seemed partly to compromise their designs. They often used too many components to fulfil a simple function. The experts also suggested that too much information could cause the designs more and more complicated until they finally lost their usability.

To solve these problems, the experts suggested supporting designers with an AT online database to improve their knowledge of AT. They also suggested giving the designer more time to finish their work. They pointed out that combining the database, which contains huge amounts of information about ATs, and the

knowledge learned from the empathic design process, would allow designers to produce better work.

The aim of the assessment was to find out what kind of design elements could be improved by using the empathic design process. The results of the investigation indicate that most important elements of AT could be improved to some degree by the application of empathic design, and that this applies especially to design elements such as the abilities of the subject, work requirements, ergonomic characteristics, environmental conditions and client considerations.

The results also show that the designers' work experience was related to the improvement of some elements such as the understanding of user ability and preference, ability to simplify, design integrity and the knowledge of material durability and cost. Some design experts argued that, due to policy and consumer behaviour, there were still some problems, and that the empathic design process was difficult to execute in real AT design for job accommodation. The improvements in empathic design that have been revealed in this assessment can be taken into account in future studies.

Chapter 7
Discussion, Conclusion and Recommendations

7.1 Discussion

7.1.1 General Discussion

Much research has indicated that AT could significantly improve the quality of life of people with disabilities. It could allows them to live independently, help them live in social contexts more easily, and allow them to form relationships with other people without disabilities. Some ATs could also help them in the accommodations necessary in their workplaces, helping them earn their own incomes and gaining not only financial security but also social respect.

These benefits have boosted the growth of the AT industry; there are now many new styles of AT being designed to fulfil the different requirements of people with disabilities. Furthermore, as computer technology has developed rapidly in recent decades, it has been employed by the AT industry to control sophisticated pieces of apparatus, and has also been used in the design and manufacturing processes involved in AT itself. It now seems possible that all types of physical problems can be solved with a combination of AT and computer technology.

However, while conducting the literature review in Chapter Two, the researcher found that appropriate AT adoption not only relies on good manufacturing and design techniques, but also on an understanding of user's requirements and their

environments. These are the most important and difficult issues in designing for people with disabilities.

The researcher also reviewed existing design concepts that could help designers understand their users. It was found that an empathy tool developed using the empathic design concept was very helpful to designers. However the development processes in existing research are very rough, and it was therefore not possible to confirm the tool's efficiency.

The researcher interviewed twelve Taiwanese product designers. The purpose of the interview was to discover the design methods that Taiwanese designers often use in their work and to understand their opinions of the empathy tool. The results showed that the Taiwanese designers mostly only observed their competitors' products before starting to make their own designs.

The limitations of budget and time nearly always prohibited these designers from doing user research before they started to design products. When asked their opinions about the empathy tool their answers were very similar. They felt that it was interesting, but budget and time were seen as the key issues as regards this type of research. Most of the designers felt that if they could not demonstrate that their use of the concept would increase efficiency, their employers would not allow the design team to undertake it.

AT users' opinions were also important in this research. The researcher interviewed

several people with disabilities in Taiwan. He observed the ATs they used and the environment in which they did so. He also interviewed AT users to collect their opinions.

The results were similar to those revealed in the existing literature research. The users were not satisfied with existing ATs. The main problems in the adoption of AT were the technologies' frequent unsuitability for their living environments and their failure to meet users' expectations, both of which has caused many ATs to be abandoned. Many users had tried to build their own AT, believing that only they themselves could truly know their own problems, and that therefore only self-made ATs could completely fulfil their requirements.

In the fourth chapter the researcher combined the findings of the literature review and the research results of Chapter three to analyse a design guideline and design a model for the empathy tool.

A suitable subject was then selected in Chapter Five. The researcher followed the design model to collect the information on the subject's physical condition and his working environment, and used this information to build an empathy tool. An assessment scenario was also developed in the chapter.

Two students were invited to wear the empathy tool and practice the scenario. In addition, the subject, together with two AT experts, was invited to examine the effects and give their suggestions. The empathy tool successfully limited the users'

activities and allowed them to experience the difficulties faced by the subject. In addition, the scenario allowed them to practice the difficult elements in the subject's work processes. Both tool and scenario only required minor adjustments before being employed in the next chapter.

Chapter Six was an assessment of the empathy tool. The assessment assumed that the tool could improve designers' abilities by allowing them to experience the difficulties faced by the subject. The researcher also wanted to identify which design elements could be improved by using the empathy tool.

10 product designers were invited to participate in the assessment, which was divided into three stages. In the first two, the researcher briefed the designers verbally and by video. The participating designers were then asked to wear the empathy tool and practice the scenario in the third stage.

The processes were recorded and the participating designers were asked to sketch their designs at the end of each stage. According to their professional knowledge, they were asked to give the best suggestions for the job accommodation AT design. The participating designers were also interviewed about their feelings at the end of the assessment.

The design work produced by the participants was reviewed by three AT design experts. They judged each design according to their professional knowledge and design guidelines. The researcher gave the experts evaluation cards for each piece

of design work and asked them to score them using 10 design elements. The final scores given by the experts for each piece of design work were equalised to avoid bias, and the results were then analysed to discover what improvements had been made.

Four of the resulting findings are worth summarising. Firstly, most of the participating designers improved their total scores throughout the assessments. They could achieve higher scores if the researcher gave them more information and experience, especially in Stage 3. After the researcher had provided them with the empathy tool that enabled them to experience the difficulties of the subject, the design scores clearly improved, which could be seen as strong evidence of the empathy tool's effect.

Secondly, the design elements such as an understanding of the subject's physical abilities, his work and ergonomic requirements, environment characteristics and client considerations were clearly improved after the designers used the empathy tool. This can be seen as evidence of the empathy tool's effectiveness on the different design elements.

Thirdly, the experience of design work was one of the most important issues that could conceivably affect the results of the assessment. The participants were divided into three groups according to their work experience to find out how much of an influence that experience had when using the empathy tool. The results showed that their experience was closely related to the understanding of the user's

abilities and preferences, ability to simplify, integrity of the design, knowledge of the material durability and cost of building the AT. Other elements were not very clearly related to that experience. It can be said that some design elements could be improved by using the empathy tool, but others need the experience that alone would ensure the creation of a better design.

Fourthly, most of the participants' opinions on the empathy tool were positive: they believed that it could help them make some improvements in their design work. However, basic design knowledge and techniques were still essential to an appropriate design, so information about new ATs should be updated regularly.

7.1.2 Revisiting Success Criteria

The researcher laid out the success criteria in Chapter One. We now revisit these criteria in order to assess the achievements of this research.

The first criteria concerns the evaluation of the empathy tool design model; the researcher had used this model to produce a set of empathy tools in Chapter Five designed to help AT designers understand a spinally injured subject and the accommodations necessary for him to do his job. The results show that the empathy tool passed the evaluation process. It met the requirements of the design rationale, although some of these requirements made some adjustments necessary. All the evaluators agreed that the empathy tool limited the user's activities and successfully allowed them to simulate the subject's physical conditions.

The second criterion concerned the identification of improvements that could be made after using the empathy tool. The researcher had invited ten designers to participate in the series of assessments through which the researcher identified five design elements that could be improved by using empathy tools: the understanding of the user's physical abilities, work requirements, ergonomic characteristics, environment characteristics and considerations of the user's clients.

7.1.3 Comparison of Related Work

When comparing this research to that regarding existing empathy tools, it is important to note first that many design research and educational organisations have developed tools to encourage people to empathise with the difficulties of those with disabilities. The present research adds some missing elements to this literature, such as the fact of having constructed an empathy tool design model to produce and use an empathy tool, having used scenarios to guide users to experience the subject's feelings, and customising the design for a single subject. In these respects, the present research is an improvement on its predecessors.

- *Design Model*

Although much research into empathic tools has been carried out, it is difficult to find a model for empathy tool design. Many researchers have used only their own imaginations to simulate a form of empathy, while many tools are not properly designed and cannot correctly simulate the subject's symptoms. Thus, the users could experience the exact feelings of the subject, and may lead users to construct inappropriate designs.

This research provides researchers with an empathy tool design model, combining the principles of product design, AT design and job accommodation to do so. The efficiency of the empathy tool in question has been proved through the practice and evaluation process.

- Scenario

When executing the empathic process, since the designer users received a new feeling which they never felt, which is cool to many young generations, the empathy tool therefore becomes a toy to the users. A very common situation was that, after putting on the empathy tool, users didn't really know what to do and what to empathise in the process, even though the tool had successfully given them the experience of a physically difficulty situation. Thus the efficacy of the empathy tool was not received by the user.

This research analysed the work environment and the tasks involved to construct a scenario that included the most important and difficult activities. The users were asked to follow the scenario step by step while wearing the empathy tool in order to experience the truly difficult elements of the task, not just the tool.

- *Tailoring to individual needs*

Customisation is a key principle of AT. The application of this research in Chapter Five focuses on only one subject, following the design model for producing the empathy tool that would solve his difficulties. However, most research has

concerned empathy tools designed for elderly people generally, and have therefore not focused either on a specific subject or on disabilities.

Aging is not a type of illness or disability, and elderly people suffer different types of deterioration in their abilities from people with disabilities. Weaknesses do not often result from single symptoms only: elderly people often suffer multiple physical and psychological weaknesses at different levels and in different areas of their bodies. Since the types of symptom involved are too numerous, an empathy tool's designer can only simulate the average level of weakness. However, there is no such thing as an average elderly person, so the designer may fall into the common error of mass-producing a design for this non-existent being.

7.1.4 Research Limitations

There are some limitations to the present research:

Firstly, a successful job accommodation process needs many people from various research fields to cooperate. The present research focuses only on the process of AT design without discussing other topics such as the subject's occupational education, medical condition and time management.

Secondly, the subject, as described in Chapter Five, was a lottery seller who was a spinally injured person with multiple disabilities. The reason for choosing him as the subject is that in Taiwan lottery sellers give jobs by special permission to people with disabilities; this has in fact become the most popular job for them in Taiwan. There are still many things that must be changed. For example, society cannot give

a lottery seller a perfect work environment, and the Taiwanese work regulations for people with disabilities still need more sociologists and other specialists to implement them. However, this research focuses on design issues and avoids sociological ones, as the researcher's speciality is in the former area.

Thirdly, ethical considerations prevented the research from causing the participants any physical suffering. As a result, the empathy tool used in this research had to take the feelings of the participant designers into account. Their experience of the difficulties involved may thus have been less intense than those experienced by the subject. This required the participant designers to be perceptive enough to feel and understand the requirements. Nevertheless, different personalities, educational backgrounds, cultures and life experiences may have led to variable results that were outside the control of the research. The researcher could only remind and encourage the participant designers to try their best in their designs to reduce any variations.

The above constraints highlight the need for this research, as well as explaining why it contains some imperfections.

7.2 Conclusions

The research began with a wide-ranging literature research, as well as designer interviews that were conducted to discover their opinions of the empathy tool, interviews with AT users and observations intended to review the problems of

adopting AT, and the development of a design model of empathy tool design which was used to produce an empathy tool. Finally, assessments were executed to determine the relationship between the improvement of design elements and the empathy tool.

The research goals were to develop a model for empathy tool design and to determine which design elements could be improved by using the empathy tool. In the final result, its achievements exceeded expectations. The achievements of this research can be summarised as follows:

Firstly, the research uncovered a wealth of information regarding Taiwanese designers' opinions about the empathy tool. The design education system was introduced into the country many decades ago and, due to the types of industry in Taiwan, is different to its Western counterparts. Design thinking in Taiwan is still very traditional. Designers are aware of the user-centred design concept, but limitations of budget, time and mostly the mindset of company owners does not allow them to implement user-centred practices such as the use of empathy tools for role play.

Secondly, AT users' interviews and observations indicated that they were not satisfied with their AT. Most had had experience of producing their own, as they believed that only they themselves could understand their own requirements and produce AT that best met their needs.

Thirdly, a model for designing an empathy tool was developed. The model was generated from the results of the literature review and designers' and users' interviews and observations. It was used to produce a set of empathy tools for a disabled subject's job accommodation; the final product was evaluated by the subject, as well as by AT experts and users. In the final case, the empathy tool achieved great success in simulating the subject's disabilities, and the evaluation results proved that the empathy tool design model is successful.

Fourthly, the assessment revealed that empathy tools generally can improve design elements by helping designers understand users' physical abilities (22 per cent), work requirements (26.6 per cent), ergonomic requirements (22.8 per cent) and environmental characteristics (21.4 per cent) compared to traditional design brief methods. However, designers' work and life experiences are closely related to the understanding of the user's preferences, the ability for simplification and integrity in the design, knowledge of material durability and the cost of building the AT: these elements are not easily comprehended in a physical tool.

7.3 Recommendations

Although the research successfully produced a model for designing an empathy tool for the subject in his job accommodation, the limitations of time and budget did not allow the author to perfect the research. Therefore, he recommends that there are some related topics that still require investigation.

Firstly, the design model needs more subjects to practice with. This research used

a spinally injured lottery seller as the subject, and successfully produced an empathy tool to simulate his condition. However, the results of using the tool would not reflect any changes in that condition. Therefore, the author suggests that more subjects with different occupations and disabilities should be invited to apply the model, so that a stronger body of evidence can be obtained for the efficiency of the design model.

Secondly, the designers' assessments need input from more participants than was the case in this research. Ten designers participated, most of them from product design-related industries. Although the assessment results had shown that some design elements were improved more than others, their validity would be strengthened in proportion as the number of participants would be increased.

Thirdly, different cultures could vastly alter the results of job accommodation. The research took place in Taiwan, which is a Far Eastern country, which will differ from other cultures. If the design model could be tested in various cultural contexts, the efficiency of the model could be proved.

Finally, in recent years, many new technologies relating to rapid prototypes and CAD have developed. Many of these developments could help designers produce signal products at a very low cost and in a short time, and that would be highly suitable for producing empathy tools in further research. The present researcher will continue his investigations in this field.

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Appendix A

AT Users Interview Result

Basic information		Interviewee No.	01
Gender:	Male	Age:	60
Occupation:			
The head of the spinal injury association and barrier free examiner in Yunlin county, Taiwan, and also a part time farmer on his pineapple and guava farm.			
Brief history of symptoms:			
He has a spinal injury in the 7th cervical vertebrae due to a work accident more than 20 years ago. It paralysed him beneath his shoulders. Although he can move his arms, he has only one finger that can actively be used in each hand.			
Living space / Work space			
The interviewee has a very strong level of activity and lives in his house with his wife and daughter. The size of his room is approximately 20 square metres but he does not always stay at home. He likes to go outside rather than stay at home.			

Current AT	Reason	Advisor	Feeling
Electric wheelchair	For activity in the house	Sales	After adding the urine container, he was satisfied
Specially designed scooter with a specially designed handle, switch, back door.	For travel outdoors. The original design could not protect him from the rain and sun	Manufacturer	After the modifications on the cover and electric controller, he was satisfied.
Specially designed hoist	The original design was too complicate to use	Designed by himself	The design is suitable for him, and he has suggested it to many of his friends.
Self-designed barrier free house	The mass-produced AT were too expensive and needed a wide space	Designed by himself	He feels satisfied by his design
Self-designed urine system	Could not find a suitable product	Designed by himself	He feels satisfied by his design

Abandoned AT	Reason of Abandonment	Why bought the AT
Electric wheelchair	Replaced	For activity in house
Second hand specially designed scooter	Replaced, not suitable for outdoor use	For trial
Body lift system	Too big to use in his house Too complicated to use	Suggested by sales person

Wish List
A better designed special scooter, and a better barrier-free environment

Basic information		Interviewee No.	02
Gender:	Male	Age:	50

Occupation:
Website designer in the Eagle-Fly project

Brief history of symptom:
He has a spinal injury between the 4th and 5th cervical vertebrae due to a car accident 16 years ago. It paralysed him below his shoulders, only his right hand can be raised a little.

Living space / Work space
He is living in a house with four rooms. Due to the disability, he only uses one room, the space is approximately ten square metres, with his bed, computer, electric wheelchair, and everything he uses in daily life. He hires a caregiver to take care of him.

Current AT	Reason	Advisor	Feeling
Electric wheelchair	For activity indoors and sometimes outdoors	Physiotherapist and seller	Not satisfied when start to use it; after fixing the structure of the control system base, he felt satisfied.
Specially designed hoist	The original design was too big to use in his room, and too expensive	Designed by himself	Satisfied
Specially designed computer table	To fit his bed in the room	Designed by himself	Satisfied
Head and breath controlled mouse	The original design made him uncomfortable	Designer	He feels very satisfied

Abandoned AT	Reason of Abandonment	Why bought the AT
Mouth stick	It make him feel his teeth were loose	Suggested by physiotherapist
Head controlled mouse	It make him feel dizzy after using it	Suggested by website design skill trainer
Computer table	Not suitable to use in his bed	Didn't know how to make it better

Wish List
A more barrier free environment A well designed keyboard for hand free use.

Basic information		Interviewee No.	03
Gender:	Male	Age:	28

Occupation:

Self-hire lottery seller, selling lottery tickets in the street.

Brief history of symptom:

He has a spinal injury in the 12th thoracic vertebrae due to a car accident in his childhood. It made him paralysed below the waist. As his work place could not support him with a toilet, his kidneys had become damaged in the last year and he now needs dialysis twice a week.

Living Space / Work Place

He is living in a flat in Taichung city centre. The building he lives in has a lift, so it doesn't give him any inconvenience. However, outside of the building is a crowded street. Most sidewalks are occupied by motorcycles and shops. He needs to drive his wheelchair carefully and sometimes he needs to drive it in the main road with other vehicles which is very dangerous.
His place of work is outside of a night post office. He drives his wheelchair into the sidewalk and installs his work station on his wheelchair. He needs to install and uninstall the work station every day.

Current AT	Reason	Advisor	Feeling
Electric wheelchair	For activity indoors and outdoors	Physiotherapist and seller	Satisfied
Work station	For displaying his lottery tickets	Designed and made by his uncle	It is too heavy to install and is not easy to carry to workplace

Abandoned AT	Reason of Abandonment	Why bought the AT
Manual wheelchair	Not suitable for carrying heavy stuff.	For use in house

Wish List

A more barrier free environment
A better designed work station

Basic information		Interviewee No.	04
Gender:	Male	Age:	33

Occupation:

Student, preparing for public officer exam.

Brief history of symptom:

He has a spinal injury in the 4th cervical vertebra due to a motorcycle accident while he was study at university. His body is totally paralysed from below his neck. Long term paralysis has given him very limited lung capacity.

Living Space / Work Place

He is living with his family. His parents are retired and have become his caregiver. His room is situated on the ground floor of the house. There is no barrier-free design in his house. Compared with his parents, he is tall and heavy, so taking care of him is a very difficult task for his parents.
Most of his work is done by using a computer. He uses a specially designed mouse to control his computer. Due to the fact that most of his books are printed on paper, his father has taken photos page by page using a digital camera, so he can read it by using his computer. He uses image processing software such as Photoshop to read and make notes on the digital images.

Current AT	Reason	Advisor	Feeling
Manual Wheelchair	For activity indoors and outdoors	Physiotherapist and seller	He can't control by himself, and he is too heavy for his parents to take care of him.
Mouth and breath control mouse	For controlling the computer	Therapist	It is good, but the motion is slower than a normal mouse and it is difficult to type text

Abandoned AT	Reason of Abandonment	Why bought the AT
Mouth stick	It is too difficult to control and it made his teeth feel painful	Suggested by therapist
Page turner	It only fits some size books and often makes mistakes. Also very expensive.	Suggested by therapist. The therapist said it was very useful.
Water bottle	The un-changeable water pipe makes it difficult to clean.	No other choice at the time.

Wish List

A well designed mouse for a disabled person
Well designed software that can help with reading and making notes.

Basic information		Interviewee No.	05
Gender:	Male	Age:	45

Occupation:
Lottery station owner, radio programme presenter, the leader of a disabled people society in Yinlin county Taiwan.

Brief history of symptom:
He had polio in his childhood. His symptoms are paralysis in both lower limbs, and he also has scoliosis due to his long term sitting posture.

Living Space / Work Place
He lives upstairs above his lottery station with all his family. The ground floor has no special barrier-free design, and even the toilet room has two stairs. He could only use his wheelchair around his computer desk, If he needs go to another space, he needs to use canes and a prosthesis. According to the rules of the lottery station, the owner could hire an assistant. His wife helps him as his assistant, and he still has the ability to manage the station. When he needs to work in the radio station, he uses a specially designed scooter and car.

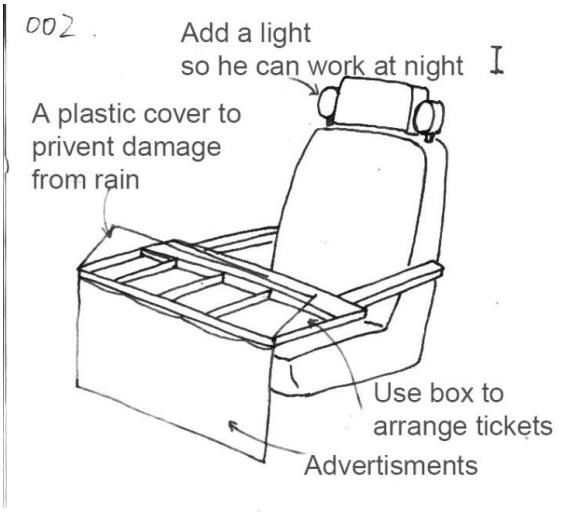
Current AT	Reason	Advisor	Feeling
Manual Wheelchair	For activity indoors and outdoors	Physiotherapist and seller	Very useful, needs a good cushion
Specially designed scooter	For work in other places	Seller, friends	Good
Canes	For going upstairs and to other rooms	Seller	Not good, but he has no other choice.

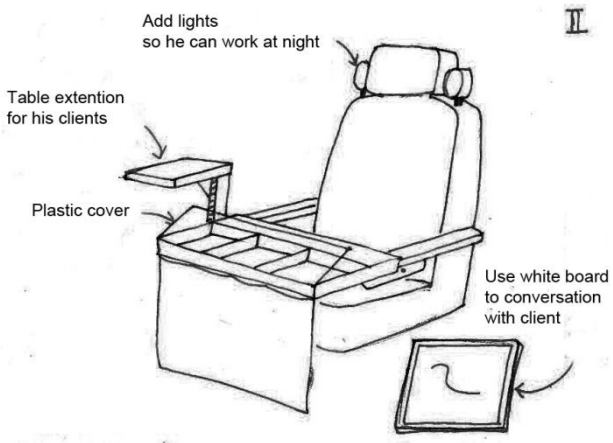
Abandoned AT	Reason of Abandonment	Why bought the AT
Self-designed wheel board	Not useful, uncomfortable	Too poor to buy a wheelchair

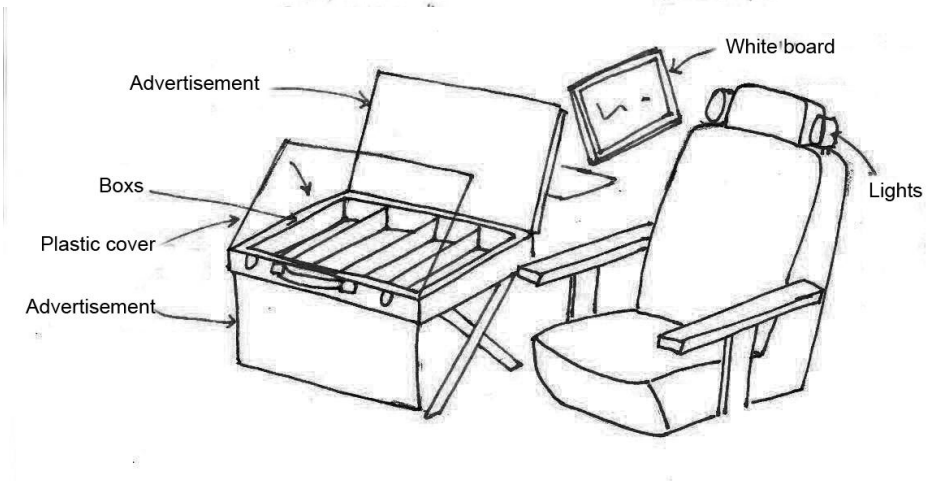
Wish List
A well designed barrier-free house A well designed cushion to make him feel more comfortable.

Appendix B

Sample of Design Works







Appendix C

Researcher's Publication in HCII 2011 (I)

Modeling the Role of Empathic Design Engaged Personas: An Emotional Design Approach

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Abstract. Norman suggested three dimensions of emotion to approach user-centred design to raise awareness of the importance of designing for users to achieve a higher level of satisfaction. In other words, the design should satisfy the user's emotional desires beyond usability. This opinion explains user-centred design more broadly. Companies, such as Apple and Microsoft, have already employed anthropologist to observe users' daily behaviour. Unfortunately, gathering information on users' needs is costly, time consuming and complex and has, therefore, become a barrier for designers. Additionally, most emotional design only covers shape design instead of all emotional aspects. There is little previous work devoted to tackling these problems. This research, therefore, proposed using empathic design with the assistance of personas as the main approach to emotional design. We first investigated the designers' current design pattern to explore the difficulties and problems. Next, personas were used to ascertain how they could help designers to engage in emotional design. Comparisons were then given to show the effectiveness of the proposed method. This study invited 16 designers to partake in this assessment. We explored how personas help designers in idea generations by using emotional design and some guidelines were suggested for future research.

Keywords: User –Centred Design (UCD), personas, empathic design.

1 Introduction

Today, user-centred design (UCD) is widely regarded as the design philosophy that defines how a design should be made by understanding the user's needs. In addition, the whole design process is examined iteratively to be user-centric by the guideline ISO 13407 to enhance the practice of UCD [1].

In the early years, the promotion of UCD was meant to solve the problems that had been encountered by some designs, those that were difficult to use and that frustrated users. Norman pointed out the guidelines for designers in his book, "The Design of Everyday Things", helping them to correctly design functions by considering the users [2]. However, he argued in his next book, "Emotional Design", that design should cover not only the cognitive parts but also human emotion. Therefore, he proposed three dimensions of emotion, visceral, behavioural and reflective, and suggested that designers should not neglect the role of the user's emotions when designing [3]. In

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other words, design should be customised by taking both users' cognition and emotion into account. Jordan also has similar viewpoints. He suggested the "four pleasures", which are physio-pleasure, socio-pleasure, psycho-pleasure and ideo-pleasure [4]. In addition, the satisfaction in function and usability is not enough to make users feel pleasure at a higher level of satisfaction. Jordan's points also indicated that user-centred design could be more complete by the explanation of satisfaction in advance. Therefore, the design is not the argument of design by following "aesthetics" or "functionality"; the proportions of the design elements are subjective to users.

Nevertheless, UCD is now used more in large enterprises even though there are several approaches to achieving UCD, such as contextual design, participatory design and empathic design. The reason is because the involvement of users makes the design costly. Most designers have a problem in understanding users when faced with them since it needs a high level of skill to arbitrate the decisions among users in a meeting and a professional background to resolve the users' behaviour during observations. Consequently, empathic design focuses on more aspects for the designers in the early stages of design. In addition, although empathic design offers "observation" as the method, the key point is to understand the users. Therefore, we only adapt the meaning "understanding of users" as the basis. To ask designers to think and behave like users could be a comparatively cheap solution as there is no "real user" involvement. Hence, the researchers suggested a method based on empathic thinking in order to help designers in the early stages of design to promote the benefits of cost effectiveness that are easy to manipulate.

This paper aims to explore the use of empathic design mixed with personas in order to help designers in the early stages of design to undertake emotional design more easily, enabling it to be more cost and time efficient. By doing this, we can persuade more usage of emotional design. 16 designers were invited to evaluate the proposed model by two-phase experiments and the experiment methods were interviews, think-aloud protocols and video recording. More findings are discussed in the results and discussion section. Through this research, we found this proposed method helped designers in emotional design and future suggestions were given.

User-Centered Design: User-centered design (UCD) is a design concept first mentioned by Donald Norman (1990). The definition of UCD is as its name implies, design according to users' needs. Norman criticised many inadequate designs that surround us and highlighted how they discouraged users from using the products. The significant difference of UCD is that it aims to persuade designers that design should consider the users' needs during the whole design process rather than adjusting users to accommodate the products. Even though more and more companies are aware of the advantages of UCD and believe UCD to be an important philosophy, the different properties of products mean that following UCD becomes a difficult task. The International Organisation for Standardisation (ISO) provides a framework in ISO13407. It suggests the human-centred design mechanism of the application and the evaluation. Although ISO 13407 offers a basic guideline for the interactive design process, it is not intended to specify the particular methods required to approach UCD. In addition, one of the major points in ISO13407 is the iterative structure of the design process, as shown in Figure 1. It clarifies how the design should consider the user during the whole process.

Emotional Design: In "Design for Everyday Things", Norman admitted that user-centred design defines design by considering the user's wants. However, at that time he only considered that products"make sense". In other words, he only suggested the guidelines for cognitive thinking. Later, Norman proposed a supplement to this in his book "Emotional Design", which pointed out the important role played by human emotions when designing interactive products. The main points of emotional design are based on three levels of emotional processing: Visceral, Behavioural and Reflective. As we can see from Figure 2, using this model we can easily reflect design elements according to emotional behaviour. In other words, different users may reflect their different desires on different aspects of design elements, such as aesthetics, functionality and usability. This can explain the reasons why some products that are difficult to use are still loved by some customers, whereas those that look good are more attractive to certain users.

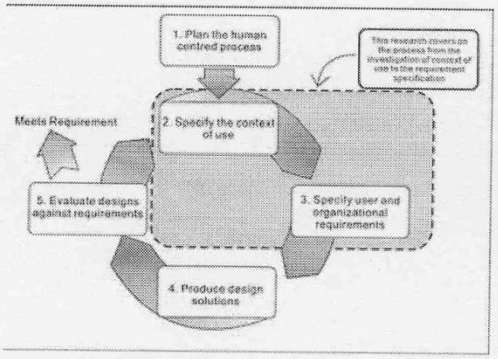

Fig. 1. The process of UCD and the area of this research [5]

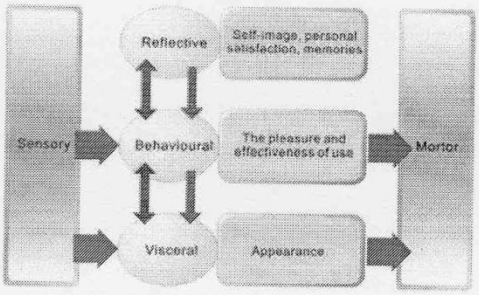

Fig. 2. The three-levels of human emotion reactions connected to the product characteristics.[3]

Empathic Design: This is an approach to UCD where the designer attempts to get closer to the lives and experiences of users and to apply the knowledge from end-users during the design process [5]. The goal of empathic design is to ensure that the product or service is designed to meet the needs of the end-users and is usable. Nevertheless, the users are only indirectly involved in the design project. It therefore tends to become 'designer-centred' instead of UCD. Additionally, professionals in empathic design promote the use of observation, although sometimes it is difficult to have the chance to freely observe the users in a particular situation. In addition to this, the involvement of users requires the design to need more skills and costs. Consequently, in this research, "personas" are used to overcome these issues and enhance the use of empathic design.

Personas: After Alan Cooper first promoted personas in his book, "The Inmates are Running the Asylum" [6], personas have been widely used in the computer science domain. Personas provide user profiles that can represent a group of people. The two main benefits of the use of personas are for communication between teams and to help designers to focus more on their users [7]. More findings, in terms of the use of personas, have been researched by Microsoft. In their work, they used personas to

develop their popular software, such as "Office" and "Messenger", finding that the use of personas was a great benefit to design tasks. In addition, famous Japanese businesses are using them for organisation communication. The authors will use personas as the key technique and, inheriting many of the advantages from work previous to this research, we intend to investigate how personas can help a designer to develop their product concept in their individual work. This research will analyse the aspects that the individual designer can use to connect with emotional design, especially few scholars contributed in the area that the process of the use of personas with emotional design.

2 Methods

By reviewing the literature we will propose methods for this assessment. There will be a two-phase assessment. First is to investigate the current design pattern of the participants. The second will be to apply the proposed model to observe how designers conduct the idea generation. We will then compare the differences before and after the use of the persona-method to reach the conclusions.

2.1 The Proposed Method: Empathic Design with Personas

We have arranged a two-phase experiment. In the first phase, we aim to survey designers' current design patterns. During the second phase, we will conduct the proposed method and then make comparisons in order to further evaluate the effectiveness. The plan of the experiment is showed in Figure 3.

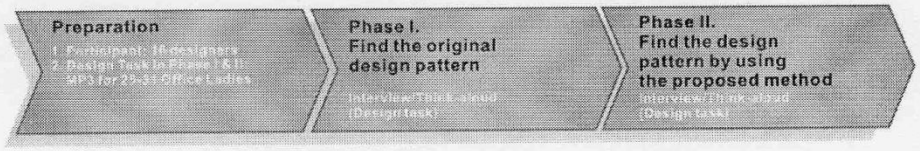

Fig. 3. The Illustration of the assessment plan

16 designers participated in the assessments. Even though this research can apply to various product categories, some control factors were defined in order to examine the comparable information in this assessment. Firstly, we assigned the same product in all the design tasks in which designers were asked to develop their product concepts. Additionally, the interviewees were required to have a similar background and to be able to manage the development of a design concept for a single product. Moreover, the designated task was confined to designing a product for use by an individual instead of a multi-user product. Also, the specified design task needed to cover all the elements of "appearance, function and usability". Each participant spent about 30 minutes undergoing interviews and the design tasks. A personal use product was specified to simplify the use of the personas. The design task needed to contain the appearance, function and usability in order to project the three emotional layers. Due to the criteria mentioned above a portable MP3 player for the group "pages 25-34, office ladies" were selected as the experimental task.

2.2 Phase I: The Investigation of the Current Design Pattern

During this phase, semi-structured interviews and think-aloud were undertaken in order to acquire details of the interviewee's background.

2.3 Phase II: The Investigation of the Use of the Persona

The second phase is to introduce the personas in order to investigate how they can help with the design task. Before the task is examined, some assumptions are proposed: The designers are trained to have the design common sense to design and they are assumed to have the imagination for the operation of fictional characters. Otherwise, the participants and the target task remained the same as for the first phase. The persona should be developed from the anthropology survey, except for the name and the photo, according to the previous literature. This is to avoid stereotyping a persona from familiar names and photos. Additionally, for reasons of ethics, it is essential to protect any private and personal data. Therefore, this study licensed photos from the FERET database (Figure 4. left side). The names were chosen from the most popular UK names on the website. The profile of the persona was taken from a lady who was located in our target market segment. Due to the limited task time available, the authors only assigned one persona, as the illustration on the right side of Figure 4. shows. Task 2 took 10-15 minutes and the participants were asked to design, applying the same conditions as the first phase. The only difference was they needed to develop their concept using the specified persona provided. The persona is located within the same market segment, "25 to 34 year-old office ladies". The point of this research is the investigation of the interaction between designers and the personas and the creation of personas is another big process.

3 Results and Discussion

3.1 The General Background and the Context of Design from the Interview

Thirteen of the designers were from Asia, two of them were from the UK and one was from the US. As we can see from Table 1, industrial designers were interviewed in the first and second phases. Within the group there were eleven senior designers with more than five years of work experience. Five of the group were junior designers with between six months and up to five years experience. The final group member was a senior design student who had only run independent design projects and group projects.

However, six designers felt that they needed to study the market on their own before they designed. Consequently, to avoid unfairness in the experiment, the researchers confined the task. We provided the same product information and only asked them to develop their product concepts.

Furthermore, the designers were asked to describe their present methods of practising idea generation and their general design cycle for a project. Interestingly, when the question was asked, "Does the user matter in your design projects?", only six of them answered "Yes", whereas nine responded that they did specify users but tried to

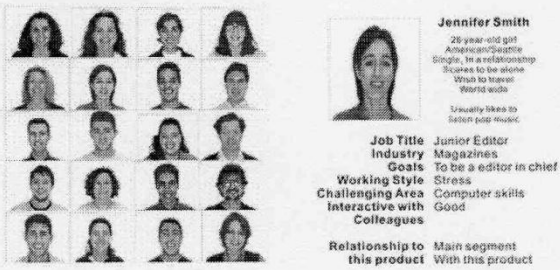

Fig. 4. The left side is example photos from the FERET database. The right side is the persona in this task.

Table 1. The background of the participants

Samples	Work Experiences	Project Lifecycle[2]	Idea generation methods	Emotional design
1	Senior	1-3m	Similar work gathering	C
2	Junior	1-3m	Brainstorming/Similar work gathering/ Scenarios/sketch	C
3	Junior	<5m	Similar work gathering/Sketch	A
4	Senior	1-3m	Brainstorming /Similar work gathering	C
5	Senior	1-3m	Sketch/Discussion/Similar work gathering	C
6	Senior	1m	Sketch	C
7	Junior	1m	Sketch	C
8	Student	1-2w	Sketch /User data gathering	C
9	Senior	3-5d	Sketch/ Brainstorming /User data gathering/ Similar work gathering/Sports	A
10	Junior	1-3m	Sketch/ Brainstorming /User data gathering/ Similar work gathering	C
11	Senior	>6m	Sketch/ Brainstorming /User data gathering	C
12	Senior	1-2m	Sketch/ Brainstorming /User data gathering	C
13	Senior	2-3m	Sketch/ Brainstorming /User data gathering/ Similar work gathering	C
14	Senior	1-3m	Sketch/Brainstorming/User data gathering	C
15	Senior	1-4w	Sketch/Brainstorming/User data gathering	C
16	Senior	1-3m	Sketch	C

ensure the design covered all user groups in order to gain maximum benefits. This demonstrated the current design problems that designers were usually asked to do design greedy cover the market. The final participant believed that users were not important in their design. We also asked them how much they understood emotional design. Surprisingly, only one of them showed an understanding. Most of them either said they had never heard of it or they had heard of it but they did not exactly understand the definition of emotional design. These patterns will be compared in the design task to see if the interview answers were identical to their design behaviour.

With regards to the design behaviour, several methods were used to inspire design ideas. Most of the designers tended to get the design concept by sketch, brainstorming and information gathering. Later, we gave them a design task that followed their

[1]*Work experience:
1. >5 years: Senior
2. <5 years: Junior
3. School project student[1] don't know what it is.[1]

2 Project Lifecycle:
m:Month
w: Week
d: Day

3 Emotional design?
A: I cam do it
B: I knew it *but I don't know* how to do it
C: I've never heard of it/ I've heard it but I

current methods. Before doing this task, a question was asked in order to record whether they had designed a similar product before. Four of them had designed once for the same market segment and two of them had designed the same product. This information was taken in order to record whether their memory of the previous design affected and contributed towards any bias in the design process that we asked participants to do. We asked them to do the same task twice to compare how useful the personas were.

3.2 Results from Phase I: The Investigation of the Use of the Persona

Table 2 shows how the designers developed their product concept using their current methods. As can be seen, six of them were product-centred, which means the designer only considered the product elements to make it pretty, regardless of the user. Three of the designers tended to be designer-centred with five tending to be both designer-centred and user-centred. Finally, two of the designers were user-centric but were easily distracted.

When analysing the interview results, we found that one of the weaknesses of the designers' present work is that, regardless of their experience, there was less user-centred design. When we examined the status of the user-centred designers, when interviewed, the participants expressed that they were designing for the users. However, during the design tasks, the UCD designers were, unconsciously, designer-centred rather than user-centred. Another finding was that even though two of the designers said they had undertaken emotional design before, they actually regarded that "appearance design" meant emotional design. Another drawback was that most of the designers were concerned with the design shape rather than functional design. Hence, we may summarise that the designers, without the support from a user research team, tended to ignore the users in their design.

3.3 Results from Phase II: The Investigation of the Use of the Persona

The design task followed the same conditions as the previous task. The results are shown in Table 3. As we can see in Table 3, when a persona is used, the design concepts from designers became similar in all aspects. However, they still had different ideas for their designs.

As shown by the information in the table and from interviews and observations, the designers were able to explore more design ideas. Additionally, the designers were found to use shorter timescales to make decisions. There might, however, be some errors attributed to the training effect due to the same product for the same users assigned to the same users twice. However, the supportive point from the interviews is that three of them had done the "MP3" project for the same group and one of them had designed the same product for a different group. However, there was no significant difference to the other designers.

One more important finding came to light when they were asked whether they felt the later concepts they made contradicted the previous task. All of the designers who were designer-centred and product-centred felt that the later designs were more likely to be suitable for the target users. However, the designers with more UCD in Task 1 said they did not feel there was a contradiction. They felt that Task 2 helped them to specify a design concept, such as a warm colour domain or a specific colour.

Table 2. The context of idea generations

Samples	Colour Scheme	Form	Special Functions?	Style/Tactile
1	Blue	Simple like an iPod	Wifi/ Convenient	Fashion
2	White with some pattern	Not specified	Not specified	Organic
3	Red or Pink	Sweet/ Stylish	Not Specified	Feminine and Elegant
4	Cannot decide now	Not specified	Simple MP3	Feminine
5	Black, to cover wider variety of users	Smooth/ Technology	Sound quality/Easy to play	Shiny surface for acceptance by the market
6	Pink series or multi-coloured mix	Round/ Delicate/ Match the dress	Simple keys	Elegant
7	Soft colour such as pink or white	Accessory	Friendly interface.	Plastic but metallic look
8	Red/Pink	Lipstick look	Simple buttons to operate	Shiny Plastic
9	Feel happy/pink series	Simple/Neat/Accessory	Easy interface and to charge up	Delicate/ Fashion
10	Many colour selections such as red/pink series	Simple/ Clear	Can be used on the bus	Metallic
11	White series/ Shiny bright series/Pink series	Round/ Friendly/ Slim/Neat/ Easy to carry	Easy interface/ Shortcut to save files/ Rapid wireless to download albums	Rubber / Leather (soft feeling)
12	Silver +Black	Simple	Internet /Plug and Play and auto sorting	Metallic +Plastic
13	Cannot decide now (Multiple selection)	Simple like an iPod/ Square	Easy key/Touch panel	Plastic but metallic feeling
14	Pink/Feminine colour	Accessory to match the handbag	Bluetooth/Can have a mirror	Shiny/Plastic
15	Light pink	Curved	Not important	Comfortable
16	Silver and Green	Rectangular	DAB, Re-corder/Subwoofer/Camera/Digital frame/ Lighter	Metallic and plastic

Regarding the emotional design, here we listed an example from participant 4. As we can see from Figure 5, we can see the context of the design. Unlike most of the present emotional products in the market, this design can further touch the behaviour level of emotion rather than only "appearance design". This result is significant as it shows the mixed used of personas with empathic design can guide designers to reach empathic design without much training. Even if we only reviewed the interview data from participant 4, other participants showed similar results and we found that inspired ideas can connect to both the reflective and behavioural levels.

The designers would get a general image of this user by the photo, name and essential profiles, such as age and gender. Then they gave a rough appearance and sensory design. When the designer looked through the detail, they usually narrowed down the ideas in relation to the reflective part. Furthermore, they started to get inspiration from combinations of the details in order to provide a functional design, which is mapped to the behavioural level. However, we have no clues from the interview that they can do the visceral design by the provided personas.

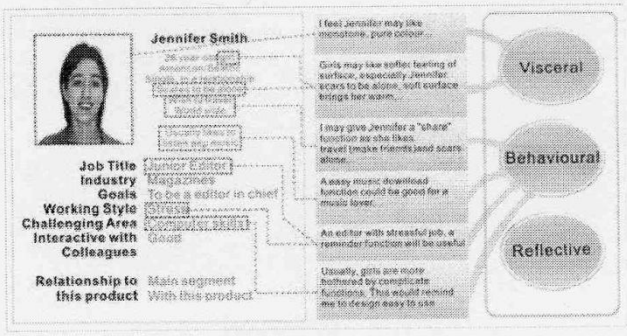

Fig. 5. The context of design in related to the persona

Table 3. The context of idea generations by using the personas

Samples	Colour Scheme	Form	Special Functions?	Style/Tactile
1	White	Like a T-shirt	Wifi/ Convenient	Clothes feel of material
2	Red	Rectangular/ Small	Agenda/Reminder/Schedule/Inspire d quote to cheer up her mood	Plastic
3	White	Organic	The ability to share functions with friends	Some pattern on the plastic
4	Monotone/Simple	Rectangular/ Bigger screen but lightweight	Touch panel/ Reminder/Easy operation/ Music download /Share	Soft Surface
5	White	Smooth/Porta ble	Easy/Good sound/Enough music storage	Shiny Surface
6	White	Round	Play/Radio	Plastic
7	Pink	Cosmetic box	Easy keys	Shiny Plastic
8	Pink	Lipstick	Simple play Earphone design resembles earrings	Plastic/Looks elegant
9	Cute Pink	Small/Portable /Rectangular	Update files easily	Fashionable/ Leather
10	Red/Black	Simple	As simple as it can be	Simple/Elegant and professional looking/ Metallic hair silky
11	Light bright colour	Round smooth/ Square	MP3/Recorder/ Calorie measurement	Shiny plastic/Metallic look
12	High contrast colour with grey	Round smooth/ Square	MP3/Photo viewer Internet friendly/Upload and download friendly	Soft material
13	Pinky white with a flower pattern	Round smooth/ Square	Easy buttons with big touch screen/Photo Viewer/Sharing function	Shiny plastic
14	White with pink	Round smooth/ Square with curve for easier handhold	News/Music downloading from the internet	Soft on the back side for easy grasp/Shiny mirror screen
15	White with pink blue/red/orange /purple	Sportive	Calorie calculation Changeable cases for different moods	Soft material
16	Pink brown	Simple neat square	Small games to kill time	Soft material

In general, the participants were satisfied with the use of personas and felt surprised at the effect of them. They commented that the personas did help them to think about users' emotion all the time without distraction. Also, they felt that this tool can help them towards self-communication and enable them to examine the ideas they made.

From the comparison of the task before and after the use of the persona, as we can see in Tables 2 and 3, we can see the design tendency converged to a similar colour domain in aesthetic design; functions are fruitful but still stick on the users. In addition, when designers undertook the task using the persona, they tended to design quicker and concentrate more.

4 Conclusions

We found the original design made it more difficult to approach user-centred design and, as a result, it was a less emotional design. In addition, most current emotional design only guides users to undertake appearance design. Instead, this method is able to lead designers to undertake emotional design without needing to be taught further design knowledge. This assessment provided the demonstration of the process of the idea generation engaged personas to launch emotional design.

In addition, this paper suggested that continuing on from this research, more characters of personas can be chosen to explore more evidences of how the personas engage with emotional design. Especially the visual personas and the profiles personas seem to provide different inspirations to designers. In addition, a complete product process can be undertaken to further assess the product with consumers.

Acknowledgment. We wish to thank the database provider, Face Recognition Technology (FERET).

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Appendix D

Researcher's Publication in HCII 2011 (II)

An Empathic Approach in Assistive Technology to Provide Job Accommodations for Disabilities

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Abstract. When the psychologist Abraham Maslow first defined the five levels of human need in 1943, people started to realise how human needs should be fulfilled and many products have since been designed to fulfill these needs. Many researches have shown that the desire to achieve a higher level of need is no different between normal people and disabled people. However, social benefits only support a disabled person with their basic needs. To help them achieve a higher level of need, for them, finding a suitable job is the best way forward.An appropriately designed assistive technology (AT) allows the user to be more efficient at work, prevent them suffering occupational injury and enjoy a safe and comfortable work environment. It could be a good tool to help them reach their psychological needs, but designing an appropriate AT requires a designer with a high level of professional knowledge in AT, an understanding of the subject's abilities and being able to realise the task and environment that the subject needs to work in, all of which involve long term training. Additionally, the majority of designers are healthy people; it is very difficult for a healthy person to have the ability to understand the difficulties of a disabled subject, especially young designers. In this research, the researcher used a spinal injured lottery seller in Taiwan as the subject. The researcher observed and analysed his tasks and environment, collected professional suggestions from experts and, based on the user-centred design theory, compared the physical differences between the subject and healthy designers. Additionally, the results were applied to a design and an empathy tool was produced, when wearing it would allow the designers to empathise with the inconvenience of the physical conditions of the subject. The empathy tool was tested and evaluated by various product designers. The researcher designed a scenarios process and asked his participants to practice with it. The result showed that although the suit could not simulate the psychological conditions of the target user, it was, however, successful in mimicking the physical conditions of the subject and allowed the designers to realise the difficulties and problems of the subject through the simulation process. Thus, these experiences were transformed into design knowledge when designing assistive technology.

Keywords: Assistive technology, Empathic design, Disabilities.

C. Stephanidis (Ed.): Posters, Part I, HCII 2011, CCIS 173, pp. 363–367, 2011.

1 Background

Job accommodation in eastern culture has a very long history. However, it was not officially managed by governments in the past and disabled people often found it hard to find a suitable job. On the one hand, according to traditional eastern thinking, no one is abandoned by God and every person should contribute to their society. This means that a person who has no "real job" will face strong pressure from their family and community, even if they have a disability. On the other hand, the help and support given by government and welfare services are often only enough for survival, meaning that disabled people need to earn a more sustainable income for their future life and family. Moreover, the ability to live independently is always the first thing that disabled people desire as earning money for themselves and their family enables them to gain people's respect and fulfill their higher psychological desires.

Sometimes, the process of helping a disabled person back to work requires the use of assistive technologies (AT) to support them within their work environment. However, many practical researches have found that most ATs are abandoned by their users after a very short period of usage.(Kintsch, A & dePaula, R, 2002) One of the main reasons is that the assistive technology bought is unsuitable. It has also happened that, in many job accommodation cases, users and their employer are often unsure which AT is suitable for the job. Consequently, when a wrong decision has been made, in some cases, it is just a waste of money. However, in more serious cases, it can often cause an occupational injury to the user.

An appropriate job accommodation design could avoid this problem. It would consider a user's physical character, work conditions, reasonable cost and work environment and would use professional knowledge and information to make an appropriate job accommodation assistive technology (JAAT) design. Moreover, an experienced job accommodation designer has more AT knowledge than the user himself and, with great vision and professional knowledge, he would know which kind of AT design would not damage the user's physical condition, even if it might make the user feel uncomfortable when they first try the AT.

However, it is not easy for an ordinary person to become an experienced designer and even experienced designers have difficulties in understanding some of their users' requirements and will sometimes make mistakes when designing the AT. Since there are so many varieties and types of disability in the world and every disabled person has different symptoms, working conditions and environment, designers find it hard to understand all situations. Therefore, in order to develop a suitable design rationale, the ability to understand the real needs of the disabled user is essential.

The empathic design model provides a process for designing commercial products and services. The model uses observation, simulation and role-playing techniques to help designers empathise with their users. It has been widely used during the design process of motor vehicles in many motor companies and it could also be employed in the process of designing AT for job accommodation.

When the empathic design model is employed to design a JAAT, the designer could use equipment to observe and record the environment but accurate simulation and role-playing techniques often require certain tools to help the designer to practice the real physical conditions and difficulties of the work environment. The precision of

these tools could deeply affect the design results. Therefore, an appropriate tool design method plays a very important role in the process.

To make an appropriate tool design, the process has to consider the user's real physical condition and work environment and compare the differences between the disabled user and the health designer, whilst also collecting professional suggestions from the medical profession and the users' employer. Finally, the designer must use their product design knowledge to design and produce the design.

The goal of this research is to build an empathy tool which could help designer to understand the working difficulties of their disabled user; the result of the development process will be analyzed in order to build a design model of empathy tool design.

2 Research Methodology and Process

2.1 Subject Selection

To achieve the goal of research, the researcher selected a spinal injured lottery seller in Taiwan as his subject; since the lottery selling is a special permit job for vulnerable people in Taiwan. In addition, the lottery company does not provide them any equipment for their special needs. Therefore, an empathic design process to unfold their real need and help designer to build an appropriate AT for their job is essential.

The subject is a lottery card sales person with T12 spinal injured by an car accident in his ten years old, and he has moderate conversation difficulty because of his stone deaf. He has selling the lottery ticket for more than ten years at the outside of a night post office in Taichung city, Taiwan.

2.2 Literature Research

The existing literature review suggested that the job accommodation process should consider the physical and mental condition, abilities and preferences of the subject, the environment, employers, and the capability of the job; an appropriate match of these conditions could reduce the difficulties of the job accommodation.

Koskinen's research also indicated that "The key to empathic design is an understanding of how the user sees, experiences and feels some object, environment or service in the situation in which he or she uses the object" (Koskinen. I et. al, 2003). To make a successful empathic design is to allow the designer to step into users' world, and to wonder around in it then to step back as a designer. Therefore, the empathy tool is the most essential equipment to help designers to do it.

2.3 Designer Research

In order to make the empathy tool correctly, the researcher analyzed the physical conditions of the subject as well as the ordinary designers. He observed and interviewed the subject and his care givers to collect the information of the subject. In addition, the Taiwanese Laborer Body Statistics Database (IOSH, 1996) is used to gather the mobility data of ordinary Taiwanese designers. By comparing the information from both sides, the researcher identified the differences of ability between the subject and ordinary designers.

The researcher also observed subject's work environment and his working process, and analyzed the tasks of the subject to find out the difficulties of the subject in his work. The results of task analysis indicated that the most difficult parts are installation of the work station, communication and un-install the work station. The identification of both his physical difference and task difficulties helped the researcher to develop the concepts of the empathy tool.

2.4 Design Rationales

Because the empathy tool is designed for general designers, the universal design principles were employed. Hence, the design rationales of the empathy tool design are:

- It should allow general designers to use.
- It should fit the sitting space of a standard wheel chair.
- It should limit the mobility of designer's lower limb.
- It should limit the designer's waist activity
- The construction of it should be able to afford the physical strength of ordinary health designer.
- It should not harm the users.

2.5 Empathy Tool Production

The empathy tool which the researcher designed and produced is separated into three parts to limit the mobility of waist, knees and ankles of designers; all of them are produced in the plastic workshop of the De Montfort University, Leicester, U.K. The main structure is built of PVC boards, and it used vacuum forming and cutting skills to construct; Nylon straps and click lock are also used to fix designers' activities.

Without a proper scenario, the empathy tool may only let its users fool around in the subject's world. Therefore, the researcher also developed a role play SOP from the task analysis; it instructed the users what to experience step by step and gave a description of environment settings.

3 Evaluation

The empathy tool was tested and evaluated by product designers, assistive technology experts, and the subject. The results indicated that the empathy tool has enough strength to stand the muscle strength of designers, and designers did not feel uncomfortable in the empathy process; moreover, it successfully limited the activities in waist, knees and ankles of the participant designers.

4 Discussions

Regarding the views from the disabled subject, the subject appreciated the empathy tool design and believed it could simulate his situation for the designer users; the assistive technology experts suggested the researcher to shorten the waist part of the

empathy tool as the subject is injured in T12, the mobility of spine should extend to the lower end of the chest; one of expert pointed out that the paralyzed lower limbs are without nerve feedback and muscle strength, which is different with the rigid constrain that the empathy tool made. However, the empathy tool designed to bend the lower limbs of the users in 90 degree angles, the users are very difficult to stand up without the help from others; they can only use their upper limbs to move body when they want to change positions, which is very similar with the experience of losing the muscle strength in lower limbs.

5 Conclusions

In conclusion, an empathy tool for simulating the spinal injured lottery seller subject has successfully made through this research; although it is very difficult to let a health designer to experience the paralyzed limbs of the subject, the empathy tool has let designers experience the difficulties of the subject without damage their body; the process of the empathy tool design has also be analyzed become a design model for further research of assistive technology in job accommodation.

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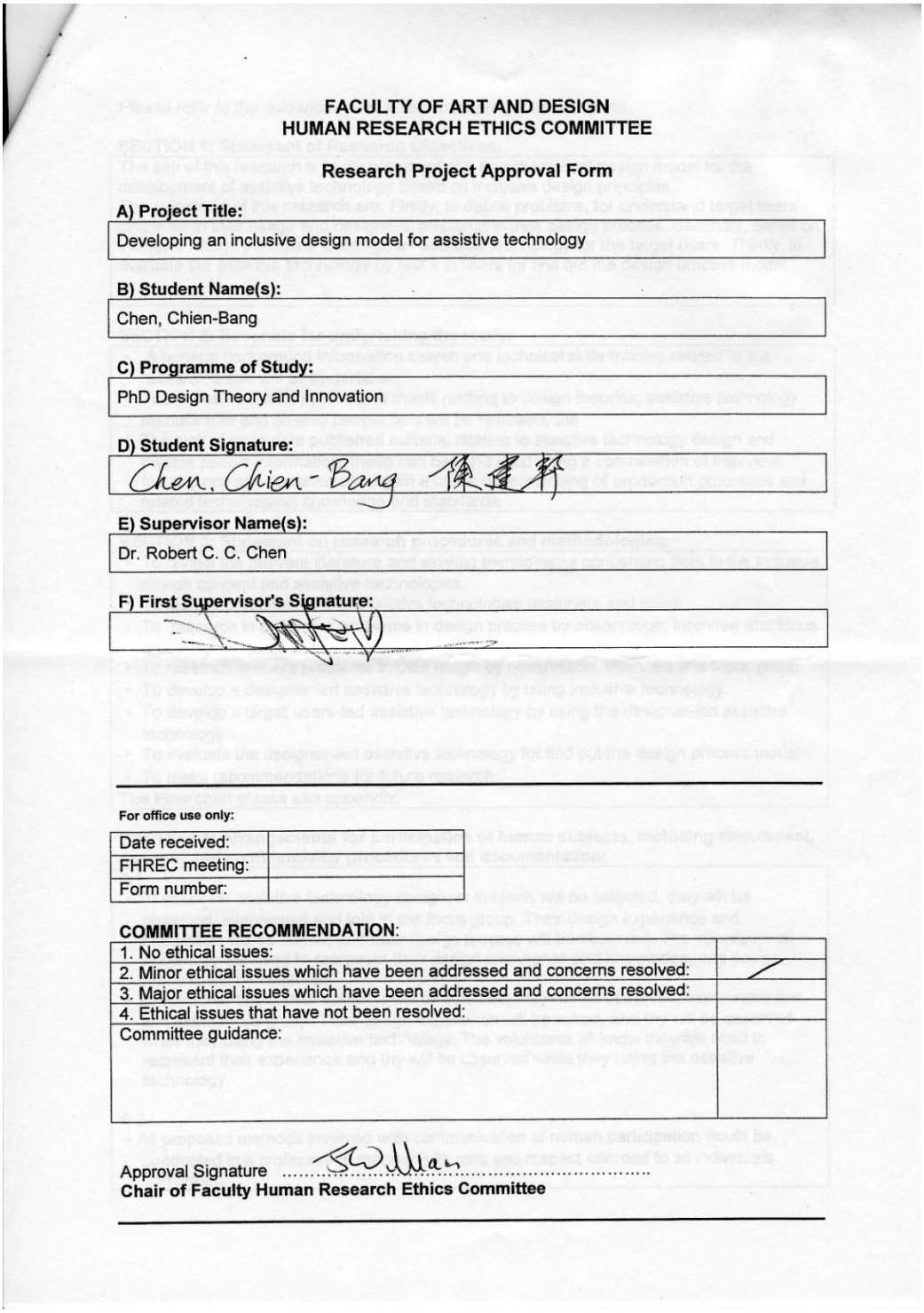
Appendix E

Ethics Approval Form



FACULTY OF ART AND DESIGN
HUMAN RESEARCH ETHICS COMMITTEE

Research Project Approval Form

A) Project Title:

Developing an inclusive design model for assistive technology

B) Student Name(s):

Chen, Chien-Bang

C) Programme of Study:

PhD Design Theory and Innovation

D) Student Signature:

Chen, Chien-Bang 陳建邦

E) Supervisor Name(s):

Dr. Robert C. C. Chen

F) First Supervisor's Signature:

For office use only:

Date received:	
FHREC meeting:	
Form number:	

COMMITTEE RECOMMENDATION:

1. No ethical issues:	
2. Minor ethical issues which have been addressed and concerns resolved:	✓
3. Major ethical issues which have been addressed and concerns resolved:	
4. Ethical issues that have not been resolved:	
Committee guidance:	

Approval Signature .....
Chair of Faculty Human Research Ethics Committee

Please refer to the guidance notes when completing these sections.

SECTION 1: Statement of Research Objectives:

The aim of this research is to development of a new theoretical design model for the development of assistive technology based on inclusive design principles.
The objectives of this research are: Firstly, to define problems, for understand target users' problems in their usage and designers' problems in their design process. Secondly, based on inclusive design principles to design an assistive technology for the target users. Thirdly, to evaluate the assistive technology by test it in users for find out the design process model.

SECTION 2: Rationale for undertaking the study:

- A general background information search and technical skills training related to the research areas will be undertaken.
- The books, research papers and thesis relating to design theories, assistive technology manufacture and disable people field will be reviewed, the
- The lack of up to date published material relating to assistive technology design and disable people information, these can be conducted using a combination of interview, focus group and observation to gain a better understanding of production processes and related technological knowledge and standards.

SECTION 3: Statement on research procedures and methodologies:

- To review the relevant literature and existing technologies concerning both in the inclusive design concept and assistive technologies.
- To identify problems both in assistive technologies designers and users.
- To research in designers problems in design process by observation, interview and focus group.
- To research in users problems in their usage by observation, interview and focus group.
- To develop a designer-led assistive technology by using inclusive technology.
- To develop a target users-led assistive technology by using the designer-led assistive technology.
- To evaluate the designer-led assistive technology for find out the design process model.
- To make recommendations for future research.

The Flow chart please see appendix.

SECTION 4: Arrangements for participation of human subjects, including recruitment, consent and confidentiality procedures and documentation:

4.1

- 20 volunteer assistive technology designers subjects will be selected, they will be observed, interviewed and join in the focus group. Their design experience and knowledge will be asked, and their design process will be observed. The volunteers all know they will need to represent their design experience and knowledge, and design process will be observed.
- 20 volunteer target user subjects will be selected, they will be observed, interviewed and join in the focus group. Their usage experience will be asked, and thy will be observed while they using the assistive technology. The volunteers all know they will need to represent their experience and thy will be observed while they using the assistive technology.

4.2

- All proposed methods involved with communication of human participation would be conducted in a professional manner with care and respect afforded to all individuals concerned.

- In cooperation with participants, the researcher will ask for permission from participants through formal documents before the research progresses and present an introduction to and outline of the research for the participants in advance and during the study if the participants choose to withdraw from this study at any time for any reason, not be used in the analysis unless removal of the data is logistically.

4.3

- Participant in this research will be kept confidential by the researcher. The researcher himself will do all transcription work and to avoid the leak of the participant's personal information during the transcription participant names will be replaced with code numbers. Thus, the results of the study, published or unpublished, will in no way identify a participant.
- Moreover, during the research the personal data, tape/photographs/video recordings and transcripts will be stored in a locked desk in the researcher's home or office. Other than the researcher, only the supervisors will have assess to the raw data.
- In addition, data will be held for the period of the research and will be destroyed after 3 years after the research by shredding, erasing tapes and deleting electronic files.

Please return your completed form to:
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